AN INVESTIGATION OF TRANSFER EFFECTS OF GIVEN AND DERIVED CODING PRINCIPLES AT THREE LEVELS OF MENTAL ABILITY

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By

Stephen O. Krebs

AN ABSTRACT OF A THESIS

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ABSTRACT

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A study of transfer of coding principles was conducted to compare the transfer effects of two methods of initial learning. In one method the subject was required to learn the principle by deriving it through study of its application to a message. In the other learning method the subject was given a written functional statement of the code principle with the code item. Both methods were tested with the same subjects but with different principles. The subjects were ninth grade students.

Initial learning was provided in a coding principles test prepared in two forms to provide control for differences in difficulty of items presented with and without the written statement of the coding principle. The transfer test was made up of items of the type used in the first test but no statements of the principle were given. Each item provided a coded message for derivation of the code principle and an uncoded message to be written in the code. The same twenty-four principles were used for both tests.

The study also examined the influence of the level of academic ability of the subject upon transfer of coding principles. For this purpose the ninety experimental subjects were assigned to low, average, and high ability groups according to their IQ's as measured with the California Short-Form Test of Mental Maturity.

The study also examined this evidence concerning the relative permanence of the transfer effects.

The t test was used to compare the scores of fifty-eight control subjects to those of an equated group of thirty-two of the experimental subjects. The control subjects were administered the transfer test. The experimental subjects were administered the learning test, then after twenty-four hours the transfer test. The results indicated that the difference in scores attributable to transfer from the learning test experience of the experimental subjects was significant at the .1 per cent level of confidence. Subsequent readministrations of the transfer test to both groups after one week and after seven weeks produced differences at the .3 per cent level, then at the 5.9 per cent level of confidence. Comparison of the scores of the equated groups after equivalent amounts of practice in taking the coding tests disclosed substantial differences which increased in significance with additional practice. The transfer value of Test I was not attributed to practice effect.

Analysis of variance with individual comparisons was used to compare scores of the three levels of ability.

Differences of scores attributable to difference in level of ability were found to be significant at the .1 per cent level of confidence. These differences remained significant at this level after one week and after seven weeks. A comparison of mean difference scores of the learning and transfer tests disclosed that all three levels of ability made equivalent gains attributable to transfer from the learning test. Comparison of mean gains in score from the subsequent administrations of the transfer test indicated that no level of ability had a clear advantage over another level attributable to relative permanence of transfer effect.

Comparison of given and derived methods of learning by all ninety experimental subjects disclosed that though the given principles were easier to learn transfer did not benefit one set of principles more than the other on the three administrations of the transfer test.

It was suggested that transfer value was not based on the correspondence of a method of learning with a particular set of code principles but rather upon the learning of a method of solution of coding problems or upon learning of the structural elements of code principles, such as transposition or substitution of letters.

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CHAPTER I

THE PROBLEM

Introduction

Transfer of training or transfer of learning is the process by which training in one task influences performance in a subsequent task similar to though not identical with the first. Any product of learning, such as skills, facts, concepts, principles, and attitudes, thus presumably can be transferred. Transfer may be positive or negative. Transfer is said to be positive when what has been previously learned facilitates performance in a new task. It is said to be negative when previous learning interferes with the performance of a new task.

The major problem today concerning transfer of training is the determination of the conditions and methods by which transfer is maximized. Perhaps even more important is the identification and description of situations to which transfer is desired. Most important of all is the problem of facilitating transfer by controlling conditions in such a way that the maximum possible transfer is attained. Transfer is thought to be influenced by the type of material being learned; the amount, kind, and distribution

of practice; the way in which retention and forgetting occur and are influenced; the formation of mental sets toward the learning required; the motivation of the learner; and the facilitation or interference from earlier experience. L. J. Cronbach held that an essential issue of such problems is the transfer of learning question, "What can we do to the learner in one situation that will change his response to other situations?"[1]

Education that does not transfer to life beyond the school has limited value. Wesman held that, "The existence of the liberal arts curriculum is justified on the basis of transfer value; the training given in the armed forces and in industry is formulated in terms of belief (or lack of belief) in transfer. Education in the classroom, on the athletic field, in the home - in personality as well as in intellectual or motor skills - is formulated to a considerable extent by attitudes concerning transfer."[2]

Early education in America based decisions concerning curriculum and methods of teaching on the doctrine of formal discipline which claimed that learning through

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[1] L. G. Cronbach, Educational Psychology, 1954, p. 245.

[2] A. G. Wesman, A Study of Transfer of Training from High School Subjects to Intelligence, Teachers College contribution to Education, No. 909; p. 1.

drill and memorization in certain subjects such as languages, classical literature, and mathematics constituted automatic general training of the mind for thinking and learning. This doctrine was based upon faculty psychology which held that the mind is made up of a limited number of faculties such as reason, the will, memory, and the like. Exercising these faculties through activity strengthened them. For example, practicing memorizing strengthened the memory.

More recent views on transfer have held, in one instance that transfer from one task to another occurs because learning has been associated with identical elements occurring in the two tasks. The other has held that transfer occurs because concepts and principles have been generalized to the extent that they transpose readily from one task to another.

Transfer is a concomitant of effective and economical processes of learning. Through transfer something learned can be applied again and again to new situations. This might be regarded as one measure of effective learning. As noted above the educator is concerned that transfer of all outcomes of learning - facts, principles, etc. - be encouraged and increased.

The problem of transfer of broad, abstract, and complex principles is somewhat more complex than that of transfer of more factual learning. A number of studies have

been reported of transfer of these more complex learnings. The study to be reported here is of this nature.

Statement of the Problem

A study of transfer of coding principles was conducted to compare the transfer effects of two methods of learning. In one learning method the subject was required to learn the principle by extracting or deriving it through study of its application to a message. (Principles learned with this method will hereafter be called "derived principles.") In the other learning method the subject was given a written functional statement of the code principle with the code item. (Principles learned with this method will hereafter be called "given principles.") The study also examined the influence of the level of academic ability upon transfer. Further, the study obtained evidence concerning the relative permanence of such transfer effects.

The initial learning was provided in a coding test. The two methods of initial learning compared in this study presented the same test items in two different ways in equivalent forms of the test. The learning methods were used in alternate items in each form. Each test item was presented with one learning method on one form and with the other learning method on the other form. In each item a message was presented in standard text and in a selected code. Another message was presented in standard text for the subject to encode in the same code.

The coding principles were of the general type usually associated with the sending of secret messages involving substitution and transposition of letters. It was considered necessary to use coding principles which could be rapidly solved and applied and which could be described for comparison with the usual structural nomenclature of cryptanalysis.

Subjects for the study were drawn from the ninth grade of a mid-western junior high school. The experimental group contained ninety subjects in a sample stratified into three groups according to academic ability as measured by IQ's obtained with the California Short-Form Test of Mental Maturity. The two forms of the coding test were randomly administered to the subjects in each group. Use of two equated forms provided a control for item difficulty. The performance of each subject provided measurements with each method of learning. Each subject, therefore, provided his own control for comparison of the transfer effects of the learning methods. Each ability group provided data for comparison of the transfer effects of difference in level of academic ability.

A second test was provided to measure the transfer effects. The coding principles introduced in the first test were presented again in the second test. Items in the

second test were of the same type as those in the first test but new messages were used and no statements of principles were given. Samples of both tests may be found in the Appendix.

Another group of 58 subjects took the second test but not the first. The performance of this group was compared to the performance of an equated group composed of 32 of the subjects in the experimental groups. This comparison provided a control for the influence of variables other than those provided in the first test.

The second test was readministered to all subjects after an interval of six days and again after fifty days. Statistical analysis of the measurements obtained provided evidence concerning the relative permanence of the transfer effects of the two methods of learning.

In brief, the purposes of the study were:

(a) To compare the transfer value of derived and given coding principles.

(b) To compare the influence of three levels of academic ability on transfer of coding principles.

(c) To compare the relative permanence of such transfer effects, if any.

Other research pertinent to this topic has dealt primarily with college or with elementary school subjects. Some questions about inconsistent results of research in

this area might have originated in this wide divergence of grade level. The project reported here used subjects at a point in their education between these two levels.

This project involved a number of features not used in previous studies. One innovation was the use of a sample stratified for mental ability levels in order to evaluate the influence of this factor on transfer of principles. Use of academic ability groups was suggested by the observed practice of some secondary schools, including the one from which this sample was drawn, of providing different curricular programs for students of different academic ability levels.

Another difference was the use of new testing instruments. These tests contained a new type of coding item based on different combinations of code element types differing in nature but all subject to rapid application. These items were also unique in that the messages used were controlled for length, number of dissimilar letters within a message, and number of dissimilar letters between messages within an item. The messages were also meaningful to increase motivation of subjects toward the tests.

Experimental hypotheses expressing the purposes of the study may be stated as follows:

1. More able subjects will transfer derived principles better than given principles.

2. Less able subjects will transfer given principles better than derived principles.

3. More able subjects will transfer better on the whole than average ability subjects and average ability subjects will transfer better on the whole than less able subjects.

4. With more able subjects the transfer effects of derived principles will be more permanent than those of given principles.

5. With less able subjects the transfer effects of given principles will be more permanent than those of derived principles.

6. Transfer effects will be more permanent with more able subjects than with average ability subjects and will be more permanent with average ability subjects than with less able subjects.

Significance of the study

Research on the transfer of verbal learning has only occasionally attempted to deal with the transfer of complex abstract principles. Studies which have made the attempt have frequently experienced difficulty in the identification and control of variables. The findings of such studies have appeared to show that certain methods of initial learning are superior in the facilitation of transfer.

Implications of new understandings of transfer of training extend into educational practice. The results of a study of the relative value for transfer of certain training methods may have direct implications for further applied research using these training methods with different educational subject matter. The introduction of academic ability levels has special significance not only because it might extend knowledge of the operant factors in the transfer of principles but also because the method of selection for experimental groups closely approximates customary ability grouping procedure for diversification of curricular offerings. Findings from this part of the study might suggest diversification of research design according to the academic ability level for which a course has been provided.

Basic Assumptions

Most fundamental of the assumptions basic to this study was the contention that transfer of learning does in fact occur.

Further it was assumed that the processes of learning and relearning coding principles would bear sufficient similarity to learning of other kinds of principles for this study to have meaning and possibly direct implications for research concerned with learning of other subject matter.

Definition of Terms

Code principle. The particular series of changes required to write a message in a particular code constitute the principle of the code. In alternate items of Test I the principles were given in written statements of the steps required to put the message in code.

Cryptanalysis. The study of methods of constructing and of analyzing or breaking codes. A cryptanalysis test would require the subject to perform one or both of these functions.

Decoding. The process of extracting the English text message from a coded message; breaking the code.

Encoding. The process of rewriting an English text message in a particular code.

Null. In an encoded message a letter representing a space between two letters of the English text message rather than a letter of the message.

Reminiscence. The phenomenon of increasing rather than decreasing retention with time.

Retention. The relative permanence or preservation of learning when retested in a situation that duplicates the original. Additional learning may be involved if cognition as well as recognition or repetition is involved.

Warm-up. Learning or relearning the mental set to perform a particular activity by practice in a similar

activity. J. B. Stroud[3] noted that there is loss of set involved in forgetting and that warm-up in an activity, similar in activity but dissimilar in content, prior to recall, can significantly increase recall.

Organization of the study

Following this introductory chapter, Chapter II provides a survey of the literature concerning those aspects of transfer of learning which are pertinent to this study. The organization of the experiment included in this investigation is described in Chapter III. This includes description of the design of the experimental investigation and of the subjects who took part in it. Chapter III also includes a description of the origin, structure, and administration of the test instruments constructed expressly for this study and of a pilot study which preceded the actual experiment. In Chapter IV the data obtained from the experiment are presented and interpreted. The results of the investigation and their implications for further research are given in Chapter V. A summary of the investigation and the conclusions based upon its findings are given in Chapter VI. Copies of the test instruments and of the directions for the administration of the tests can be found in the Appendix.

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[3] J. B. Stroud, Psychology in Education, Revised edition, 1956, p. 501.

CHAPTER II

SURVEY OF RELATED LITERATURE

Historically, theory of transfer has developed in four major stages. The first stage emphasized the general educational value of specific subject matter, such as classical studies, geometry, Latin, etc., with little regard to applicability to real problems. The lack of concern with transfer during the first stage may have been responsible for the apparent lack of material even indirectly related to transfer during that stage. Next there was a stage of emphasis on gaining formal or mental discipline to improve powers of reasoning, memory and judgment. Drill and memorization in the subject areas given prestigious position in the earlier stage were credited with special powers in the development and training of the mind. The third stage began with the discrediting of the theory of formal discipline. The popular theory of this stage claimed that only specific elements, habits, facts, and skills could be transferred. Finally, the fourth stage has extended transfer capability to broad concepts and understandings, and to learning how to learn. This stage has also promulgated the view that these broader

transfer media are more important than the more specific elements of the third stage. The last three stages have each made direct contributions to current transfer theory. There were certain topics of special interest to the study reported in this paper. Transfer of principles, such as methods of approach to problem solving, have received much attention in the fourth stage of the study of transfer. The influence of levels of mental ability on the transfer value of techniques of teaching has received only incidental attention. The relative permanence of transfer effect and the use of coding principles in the study of verbal transfer have received very little direct study.

Transfer and formal discipline

William James[1] (1890) questioned the validity of the type of transfer value claimed by the proponents of the doctrine of formal discipline (also called the doctrine of mental discipline). He described a method of testing this point. For eight days he memorized 158 lines of Victor Hugo's "Satyr," noting total learning time required to learn it by heart. He then spent some twenty minutes per day for thirty-eight days memorizing the first book of "Paradise Lost." Then he memorized another 158 lines from

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[1] W. James, The Principles of Psychology, 1890, pp. 664-668.

the first poem. This second section from "Satyr" required more learning time than the first. Several of his students repeated the procedure with comparable inconclusive results. He recognized that these findings were open to question because they represented the experience of less than ten subjects. He suggested that gains could be made in method of learning rather than transfer of gains from repetition as such. James[2] reiterated this opinion two years later. James[3] also suggested that though native retentiveness was not improved by practice, memory efficiency might be improved through a mental reorganization or rearrangement of experience.

Thorndike and Woodworth[4] (1901) reported a study which included several experiments. In each, the subjects were pretested with several activities. In one activity the subjects were pretested on estimating magnitudes, such as length of lines, then practiced to a high degree of proficiency the estimation of a limited range of such measurements. In another activity the subjects were pretested on ability to pick out certain symbols in a given list. These included words containing certain letters, or

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[2]W. James, Psychology, 1892, pp. 295-298.

[3]James, 1890, op. cit., pp. 666-668.

[4]E. L. Thorndike and R. S. Woodworth, "The Influence of Improvement in One Mental Function Upon the Efficiency of Other Functions," Psychological Review, Vol. 8:395, 1901.

words of a given length, or geometric figures. The subjects were then practiced in just one of these functions. In another activity the subjects memorized verbal material then received special training in memorizing. Finally they were retested with all of the activities used in the pretest to determine whether there was evidence of transfer from the specific training activities to the other activities of the same type but of different dimensions than those of the training activity or to the other related activities measured in the pretest and post test. Thorndike and Woodworth found evidence of very little transfer to the related activities. They concluded that transfer occurred only when there were identical elements in the influencing and influenced functions.[5] Thorndike (1903) defined identical elements as "mental processes which have the same cell action in the brain as their physical correlate."[6]

Thorndike[7] (1924) reported a study of intelligence test score gains made by students following different academic programs. His study included 8,564 subjects who were enrolled in grades nine, ten, and eleven of a number

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[5] Ibid, p. 250.

[6] E. L. Thorndike, Educational Psychology, 1903, p. 81.

[7] E. L. Thorndike, "Mental Discipline in High School Studies," Journal of Educational Psychology, Vol. 15:19, 86-98, 1924.

of high schools. An intelligence test was administered to the subjects at the beginning and at the end of the school year. The gains in test scores were compared for subjects whose programs were alike except for one course selection. Using many such combinations it was possible to examine the relative influence on gains in score of a number of individual courses. Adjustment and weighting of initial scores and their relation to gains were used to equate the subjects relative to initial ability.

Thorndike found that the difference between gains of those taking the most "favorable" program (bookkeeping, arithmetic, physics, and chemistry) and those taking the least "favorable" program (cooking, sewing, and two courses in biology) was less than the difference between the gains of very intellectual boys and those of average boys taking the same studies. The results of the study indicated that rather than finding that certain courses of study tended to produce good thinkers, as would be expected according to the doctrine of formal discipline, it was found that good thinkers tended to take certain courses. Thorndike held that "The expectation of any large differences in general improvement of the mind from one study rather than another seems doomed to disappointment."[8]

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[8] Ibid, p. 98.

Brolyer, Thorndike, and Woodyard[9] (1927) repeated Thorndike's first study with 5,000 new high school subjects. Procedures similar to those of the earlier study were used. The findings of this study agreed with those of the former in that the influence of taking a particular course on gain in intelligence test score was shown to be very small. The studies also agreed in finding that the more able students tended to take certain courses. The findings of these studies indicated that the claims of the doctrine of mental discipline were too broad. The outcomes of training were found to be more specifically related to the scope of the training itself.

Wesman[10] (1945) used 643 subjects in grades ten and eleven in one high school in a study which attempted a similar assessment of the comparative contributions of certain studies to mental growth as measured by an intelligence test. Repeating the high school course comparisons of the Thorndike studies produced comparable findings. This study also compared the gains in scores on achievement tests with gains in scores on the intelligence test. Correlations between gains on the two types of tests

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[9]C. R. Brolyer, E. L. Thorndike, and E. Woodyard, "A Second Study of Mental Discipline in High School Studies," Journal of Educational Psychology, Vol. 18:399-402, 1927.

[10]Wesman, op. cit., p. 260.

were uniformly low. The highest correlation was .270 between gains on a test of Contemporary Affairs and gains on the numerical phase of the intelligence test in the tenth grade group. The corresponding comparison for the eleventh grade produced a coefficient of .054. These low correlations also fail to support the doctrine of mental discipline. According to this doctrine gains in specific areas of ability should be accompanied by gains in more general mental functions such as are purported to be measured by tests of intelligence.

Judd[11] (1908) reported an experiment with fifth and sixth grade pupils. The subjects, using darts, were required to hit a target submerged in water to a specific depth. One group was instructed in the principle of refraction of light. The other was given no instruction in the principle. Both groups could see their results. After practice in hitting the target at a depth of twelve inches the depth was changed to four inches. After practice at this depth the target was moved to a depth of eight inches for further practice. The group instructed in the principle of refraction adapted more quickly to the second and third depths. Judd remarked that the experiment was not carried far enough for the less successful group to

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[11] C. H. Judd, "The Relation of Special Training to General Intelligence," Educational Review, Vol. 36:36-38, 1908.

"Overcome their confusion with every change in the depth of the water."[12] He concluded that it appeared unlikely that this group had derived a principle of the method of hitting the target which they could transfer.

Hendrickson and Schroeder[13] attempted a similar experiment with more attention to detail, using ninety boys in the eighth grade. The boys fired BB's instead of darts. Evidence was reported favoring a group given the principle over a group given the principle with less detail and this group in turn did better than a group that was required to derive the principle by trial and error. In this study each individual fired to the criterion of three consecutive hits at a depth of six inches and was then tested to the same criterion at a depth of two inches. The reductions in number of shots required to reach the criterion for all three groups were nearly equal. Hendrickson and Schroeder based their claim that transfer effects were unequal for the three groups on the per cent of reduction from the first test situation to the second. The percentages of reduction were unequal because the initial scores were unequal.

The studies by James, Thorndike and Woodworth demonstrated that the doctrine of formal discipline was not supported by empirical evidence. The purported transfer

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[12] Ibid.

[13] G. Hendrickson and W. H. Schroeder, "Transfer of Training in Learning to Hit a Submerged Target," Journal of Educational Psychology, Vol. 32:205-213, 1941.

values of formal discipline, based on a faculty psychology, were not validated. The theory of identical elements appeared to provide an explanation of what was wrong with the doctrine of formal discipline. Judd's study went a step further. He suggested that a principle applicable in the solution of a certain problem had transfer value for related problems.

Theory of Transfer

Andrews and Cronbach (1950) pointed out that for educational purposes two questions about transfer stand out. They asked first, "To how wide a range of different situations will a particular learning transfer?" and second, "What instructional methods promote the greatest degree of transfer?"[14] These writers arrived at a general theory of transfer as follows: "Transfer of a previously acquired behavior pattern to a new situation will occur whenever an individual recognizes the new situation as similar to the situation for which the behavior was learned."[15] It was their opinion that there is no superior subject matter for transfer; there are only superior learning experiences.

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[14] T. Andrews and L. Cronbach, "Transfer of Training," Encyclopedia of Educational Research, W. S. Monroe, editor, 1950, p. 1483.

[15] Ibid., pp. 1487-1488.

To increase the transfer value of learning experiences, suggestions concerning teaching methods might be expected to follow one of two theoretical orientations. Following Thorndike, those specific elements likely to recur in subsequent problems might be the major objective in teaching. On the other hand, the major objective might be to teach general principles applicable in the solution of problems. An example is the principle of refraction used in the study by Judd.

The process by which a principle generalizes to related problems is a subject of theoretical as well as practical concern. P. L. Harriman (1959) defined transfer by generalization as "the gains in skills or understandings which may be carried over to a new assignment because of the broad principles which have been adduced by the learner in previous experiences."[16] Seed for such a concept as transfer by generalization can be found in C. H. Judd's statement in 1903, in reference to the phenomenon of perception of light, that, "Past experiences have been boiled down into a very safe and practical habit of interpretation."[17]

The psychological phenomenon of response generalization,

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[16] P. Harriman, Handbook of Psychological Terms, 1959, p. 196.

[17] C. H. Judd, Genetic Psychology for Teachers, 1903, p. 55.

Mowrer[18] indicated, is sometimes regarded as transfer of training. Response generalization is the tendency of a stimulus which can elicit a given response to also elicit related responses. Mowrer[19] suggested that transfer could be expected if the two situations involved a common item of behavior but he went on to say that it is the communality of stimulation rather than of behavior which provides the basis for transfer. He explained the essential role of mediation of response in transfer in this light. For example, after referring to the sentence as a device for producing associations, or conditioning, he said there must be response mediation, "whereby the new meaning which thus gets connected to the sentence subject can generalize, or transfer, to the thing thus symbolized."[20]

R. Bruce[21] (1933) reported a study comparing the transfer value of learning associations in which the stimulus is varied to those in which the response is varied. Lists of paired nonsense syllables were prepared. The lists were paired so that certain similarities existed between corresponding pairs of syllables in the initial

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[18] O. H. Mowrer, Learning Theory and the Symbolic Processes, 1960, p. 27.

[19] Ibid., p. 40.

[20] Ibid., p. 152.

[21] R. W. Bruce, "Conditions of Transfer of Training," Journal of Experimental Psychology, Vol. 16:350-354, 1933.

learning and transfer lists. Similar syllables were devised by changing the last of the three letters in a syllable. For instance, changing "sil" to "sim." Identities were also used. For example, in a pair of lists the stimulus syllables might be identical and the responses different. In another pair of lists the responses might be identical and the stimuli different.

Each group of nine subjects was taught an initial learning list of paired syllables, then the corresponding transfer list. In this manner each group learned several pairs of lists for the same condition of similarity.

Bruce found that transfer was significantly high in learning an old response to a new stimulus. He found low positive transfer in learning a new response to a new stimulus and low negative transfer in learning a new response to an old stimulus. These findings suggest that transfer was based on stimulus generalization, not response generalization.

Studies of transfer which deal with applications in education are generally more concerned with finding specific methods which will foster transfer than with the psychological processes by which it occurs. The primary implication of the question of stimulus - response generalization for such research is the requirement of careful controls for both types of factors.

For example, a study of transfer effects might require that either stimulus or response factors be varied while the other is held constant. In this manner one could study the influence of variation in the learning task on subsequent learning of another task. The proponents of the theory of identical elements in transfer hold that teaching should emphasize those elements most likely to recur in new situations and should teach their application in varied contexts. The proponents of the theory of generalization in transfer hold that concepts, such as methods of problem solving, should be taught by application to various situations to promote their generalization to other new situations. These views are not necessarily incompatible.

Hilgard has attempted to express a view of transfer which would be acceptable to most contemporary theorists. He has said that, "Transfer to new tasks will be better if, in learning, the learner can discover relationships for himself, and if he has experience during learning of applying the principles within a variety of tasks."[22] This idea is not new. William James (1890) suggested learning in multiple contexts. He said that which is associated with one thing then another tends to become dissociated from either and to become, "an object of abstract

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[22]E. Hilgard, Theories of Learning, second edition, 1956, p. 487.

contemplation by the mind." He called this, "the law of dissociation by varying concomitants."[23] However, by their emphasis on the learning of principles both writers appear to be favoring the generalization theory of transfer.

Transfer of Principles

Ackerman and Levin[24] (1958) reported a study of transfer of principles. Two groups were taught to solve water jar problems. In this type of problem the subject is given the capacities of two or three jars. Using only the full capacities of the jars as measurements, the subject must tell how he would obtain a specified quantity of water. For example: given a five pint jar and a two pint jar, obtain three pints of water. The subject should discover that by filling the five pint jar, then filling the two pint jar from it, three pints will remain in the five pint jar. The problems were so devised that more than one method of solution was possible. One group was taught one method of solution of the problems. The other group was taught two methods of solution. The second group evidenced a significantly greater number of

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[23] James, 1890, op. cit., p. 506.

[24] W. O. Ackerman and H. Levin, "Effects of Training in Alternative Solutions on Subsequent Problem Solving," Journal of Educational Psychology, Vol. 49:239-244, 1958.

variations of solutions on other water jar problems and on subsequent paper and pencil jigsaw puzzle problems. They also tended to solve more problems though this difference was not significant. The implication of this finding appears to be that transfer to new problems is enhanced if more than one principle of solution of the learning problems has been taught.

Katona[25] reported a study of transfer of solutions to card tricks. For example, subjects were required to arrange thirteen red and black cards so that by alternately turning a card face up then placing the next one on the bottom of the pack the cards would all be turned up in alternating colors. Subjects in one group were given the solution to the trick and were required to memorize it. Subjects in another group were given the principle (the method of finding the solution) used in the solution. They were required to work out the solution to the trick. Subjects given the principles performed better in the solution of similar tricks than the subjects given a solution to memorize for the training trick. Katona held that this finding lends support to the assumption that principles are superior in transfer value to facts and routine training.[26]

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[25] G. Katona, Organizing and Memorizing, 1940, pp. 39-47.

[26] Ibid., p. 56.

E. Hilgard and others[27] (1953) reported a study conducted to re-examine Katona's results. Katona's card trick tasks were taught to one group of subjects by the method of rote memorization and to a second group of subjects by instruction in a rational method of solution.

The memorization group learned the initial task more rapidly. The understanding group demonstrated much more transfer to problem solving tasks such as setting up a pack of ten spades so they would turn up in order if every third card was turned up and the other two were placed on the bottom of the pack. However, the understanding group showed only a slight advantage in transfer to a task involving a simple transposition of the solution learned for the original task and showed only a slight advantage in recall of the original solution after one day. The investigators suggested that the recall advantage might have been greater if a longer retention period had been provided.

Craig (1953) reported an experiment designed to measure the effectiveness of various amounts of help in learning to solve verbal multiple choice items. Craig said "Four groups of fifty young men, all recent college graduates, were equated for initial performance on the learning material. Each of the four groups was then given

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[27]E. R. Hilgard, R. P. Irvine, and J. E. Wipple, "Rote Memorization, Understanding, and Transfer: An Extension of Katona's Card Trick Experiments," Journal of Experimental Psychology, Vol. 46:288-292, 1953.

a different amount of guidance, in the form of clues to bases for correct responses, during the solution of multiple-choice verbal test items."[28]

The solutions of items were based on principles of word relationships such as similarities of word meaning, words forming a familiar series, or similarities in spelling. Subjects were directed to mark successive choices on each item until it was indicated that they had selected the correct answer. The answer sheets were so constructed that when the correct answer was marked, the point of the pencil would pierce the paper.

The first group of subjects, called the Z treatment group, was required to discover the principles or bases of correct solutions to the test items without clues. The instructions for this group contained no reference to the existence of relationships determining the answers that were correct. These subjects were directed to choose from each set of five words the word that did not belong with the other four.

Craig's description of the guidance given the other three groups was as follows: "In the present experiment, items were grouped according to common organizational principles to serve as a clue for the second method group.

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[28]R. E. Craig, The Transfer Value of Guided Learning, 1953, p. 63.

Each such group of items based on a common organizational principle was separated from the others by spacing; this type of clue was called G. A third group received Guidance G and, in addition, information (X) calling attention to the fact that all items of a given group were organized according to a common principle, which determined correct responses. This combination was called Treatment GX. Finally, for the maximum guidance group, a short statement of each principle was given in addition to G and X. This combination of clues was called Treatment GXP."[29]

Craig reported that all groups receiving guidance made fewer errors than did the group receiving no clues. He reported that the groups receiving guidance made fewer errors in order of the amount of guidance received.

Craig[30] used the type of item described above in a later study. The subjects were pre-tested and post-tested with a group of four items for each of fifteen principles. The principles were of the same type as used in the former study. Two groups of college students were given different directions in the solution of items of this type during the training period between pre and post testing. One group

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[29] Ibid., pp. 64-65.

[30] R. E. Craig, "Directed Versus Independent Discovery of Established Relations," Journal of Educational Psychology, Vol. 47:223-234, 1956.

was told that the four items in each group were based on the same principle. The other group of subjects was given, in addition, a short written statement of each principle.

The period between pretesting and post testing was 38 days. The 15 principles were divided into three sets of five for training. The training consisted of solving items similar to those in the pretest and the post test. Both groups received the training on one set of principles early in the period, on the second set midway in the period, and on the third set late in the period.

The group given the principles obtained significantly higher scores on the portion of the post test covering the first training set. There were no significant differences of scores on the post test for the principles in the more recent training sets. A second post test contained ten new principles. The scores obtained by the two groups on this test were not significantly different.

Craig's findings concerning guided learning correspond very closely with the findings reported by Woodrow[31] (1927) concerning the influence of training on transfer. He studied the transfer value from undirected drill compared to the transfer from training in memorizing with practice.

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[31]H. Woodrow, "The Effects of Type of Training upon Transference," Journal of Educational Psychology, Vol. 18: 160, 1927.

Using psychology students as subjects he formed three groups. The groups were pre- and post-tested in memorizing tasks. The control group was assigned no activity during the intervening four weeks and five days. The practice group was given practice in memorizing poetry and nonsense syllables in the period between pre- and post-testing. In the training group, using the same total activity time (177 minutes) as the practice group, 70 minutes of this time were used for instruction in techniques of efficient memorizing. Woodrow found training in techniques of memorizing with practice, superior to practice alone for transfer to memorization of each of six types of material. In fact the practice group made practically no gain. Woodrow concluded that, "in a case where one kind of training - undirected drill - produces amounts of transference which are sometimes positive and sometimes negative, but always small, another kind of training with the same drill material may result in a transference, the effects of which are uniformly large and positive."[32]

Kittell[33] (1957) reported a study similar to Craig's but using sixth grade pupils as subjects. He obtained scores from a test composed of items of the verbal multiple-

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[32] Ibid., p. 171.

[33] J. E. Kittell, "An Experimental Study of the Effect of External Direction During Learning on Transfer and Retention of Principles," Journal of Educational Psychology, Vol. 48:394-396, 1957.

choice type described for Craig's studies. His test included a group of three test items for each principle. His subjects were divided into three groups for three amounts of guided learning. The minimum treatment group was told that each of the three items in a group involved the same principle and that one word out of five in each item did not belong. Kittell's example contained the choices: (a) gone, (b) start, (c) go, (d) stop, and (e) come. His directions to the subjects called for matching direct opposites so that the word "gone" would be left and, therefore, would be indicated as the answer to the question. His principles were based on meaning, sound, familiar word combinations, and word arrangement and meaning.

The intermediate treatment group was given a statement of the principle for each group of items. The maximum treatment group was also given oral statements of the correct responses. The training period included practice on a set of three items for each of three principles. Such a new set of nine items was practiced each of the five weeks of the training period. The subjects marked choices on an item until they had marked the correct choice. They were told that each incorrect response would lower the total score. Kittell[34] reported that a series of three

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[34] Ibid., pp. 397-401.

post tests was used. The first post test was a readministration of the pretest; the second contained different items based on the same principles; and the third contained different items based on different principles. The minimum treatment group scored significantly lower on all three post tests. The intermediate treatment group obtained a mean score about equal to that of the maximum treatment group on the first post test and significantly higher on the second and third post tests.

In the studies by Craig and Kittell each multiple choice question had only one answer which was considered correct. Examination of specific items (see Kittell's example given above) however may produce more than one right answer depending upon the principle the subject has in mind. Both Craig and Kittell built into their tests some protection against this type of scoring ambiguity by specifying that a group of three or four items were based on the same principle. For the groups given the principles such confusion was avoided. Though it is difficult to adequately assess the influence of such scoring ambiguity on the scores of subjects on a post test, such influence might ordinarily be expected to be negative because ambiguity, by misleading the subject, may offset adequate learning by inconsistent support in labeling answers right

and wrong. For example, Aronov[35] (1958) reported that in a study of maze learning in humans both consistent guidance and no guidance were significantly superior to inconsistent guidance in transfer of learning. Ambiguity of multiple choice grouping items has been a problem in other tests. Menger[36] has discussed in detail the nature of such ambiguities and has provided a system for their control in the design of grouping problems.

Waters[37] (1928) reported a study in which a bead counting principle was learned under different conditions. Subsequent transfer to a task involving a similar bead counting principle was evaluated. The study used only one principle for learning and one for transfer. Calling attention to a significant aspect of the problem principle or providing a short concrete statement of the principle were of more benefit in original learning and in transfer than demonstration of a solution, or correction of errors, or a longer, more general, more abstract statement of the principle.

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[35]B. M. Aronov, "The Influence of Consistent and Inconsistent Guidance on Human Learning and Transfer," Journal of Educational Psychology, Vol. 49:84, 1958.

[36]K. Menger, "On the Design of Grouping Problems and Related Intelligence Tests," Journal of Educational Psychology, Vol. 44:275-287, 1953.

[37]R. H. Waters, "The Influence of Tuition upon Ideational Learning," Journal of General Psychology, Vol. 1:545, 1928.

Kersh[38] (1958) reported a study which used two types of mathematical problems and three types of treatment. The two types of mathematical problems were "odd numbers rule" problems and "constant difference rule" problems. The odd numbers rule states that the sum of any series of consecutive odd numbers beginning with "one" is equal to the square of the number of figures in the series. The constant difference rule states that the sum of any series of numbers in which the difference between the numbers is constant is equal to half the product of the number of figures and the sum of the first and last numbers. His treatments were independent discovery (or derivation) of the principles, direct reference to the relationships essential to understanding the principles, and having the principles given orally with practice in applying them. Subjects were given practice to successful solution in three problems for each of the two types described. The subjects were tested with twenty problems of these types immediately after the practice period and again with two problems of the same types four to six weeks later. His hypothesis that the second treatment would result in the greatest transfer was not supported. The independent

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[38] B. Y. Kersh, "The Adequacy of Meaning As An Explanation for the Superiority of Learning by Independent Discovery," Journal of Educational Psychology, Vol. 49:286-291, 1958.

discovery group appeared to transfer the two principles most effectively though the difference was not statistically significant. This group appeared to gain understanding during the four to six week waiting period following the practice period while the other two experimental groups appeared to lose during this waiting period.

Sassenrath[39] (1959) reported a study of transfer of derived principles. The initial learning task for his experimental subjects involved learning a single principle, namely the number of letters in each word minus one. The subject was shown one word at a time and instructed to respond by saying a number. When the subject gave his numerical response for a word he was told whether it was right or wrong. The control subjects were shown words and responded with numbers without being informed whether they were right or wrong. This was intended to provide warm-up. The directions for the subjects also differed. The two groups were given the same basic directions to the effect that a number response was to be given to each word. The experimental group was given the additional instruction that their number response was to be a function of the examiner saying right or wrong after each response. This extra instruction was intended to create an intentional set to learn.

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[39] J. M. Sassenrath, "Learning Without Awareness and Transfer of Learning Sets," Journal of Educational Psychology, Vol. 50:206-207, 1959.

The transfer task administered to both experimental and control subjects was the learning of a new principle in the form of a reversal of the principle of the initial learning task. In this task the principle was a constant (eleven) minus the number of letters in the word. The transfer from the initial task was found to be significantly greater for the experimental group than for the control group. Thus the discovery of a principle seemed to aid in the discovery of a similar principle.

Haslerud and Meyers (1958) reported an experiment testing the hypothesis "that principles derived by the learner solely from concrete instances will be more readily used in a new situation than those given to him in the form of a statement of principle and an instance."[40] These investigators used two coding tests administered a week apart. The first, a training test in two forms, was made up of coding items for half of which the principles were given in written statements. For the other half of the items the principle had to be derived by the subject from the coded message in the item. The second test contained the same codes applied to new items. In each item of the second test the subject was required to select the correct coding from four messages,

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[40] G. M. Haslerud and S. Meyers, "The Transfer Value of Given and Individually Derived Principles," Journal of Educational Psychology, Vol. 49:294, 1958.

three of which contained letters in random order. No principles were given in the second test. Both tests were administered to the experimental subjects, only the second test was administered to the control subjects. These investigators reported that on the initial learning test the subjects obtained higher scores on the items for which a statement of the principle was given. On the second test the subjects scored approximately as well on the items with principles learned by the derived method on the first test as they did on the items with principles given on the first test. Haslerud and Meyers concluded that derived principles transferred better than the given principles. It appears possible, however, in view of the nearly equal scores for given and derived principles on the second test, that the transfer effect may actually have been equal for given and derived principles. The higher score for given principles on Test I may indicate that the given form of item may be easier to solve than the derived form of item.

Each of the above studies provided evidence relative to certain aspects of the transfer of principles. Ackerman and Levin demonstrated that teaching two principles of solution of a problem produced more transfer than teaching just one principle. Studies by Woodrow, Katona and Hilgard indicated that training in a method or principle of problem

solving showed greater transfer value than practice by itself or than memorized solutions to specific problems. The study by Waters indicated that giving a principle applicable in solving certain problems produced more transfer than demonstrating solutions to problems. Studies by Craig and Kittell showed greater transfer value from given principles than from principles that were derived from examples. A study by Sassenrath indicated that the derived method of learning was superior to practice. Studies by Kersh and by Haslerud and Meyers indicated that the method of learning principles by derivation was superior in transfer value to given principles. The findings of these last two studies are particularly contradictory to those of the studies by Craig and Kittell. It was hoped that the study reported here would provide further evidence concerning the transfer effects of given and derived principles.

Transfer and mental ability

After his experiment in transfer of training in learning to hit a submerged target, Judd concluded "that every experience has in it the possibilities of generalization. Whether the generalization will be worked out by an individual is a question of that individual's ability and persistence."[41]

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[41] C. H. Judd, "The Relation of Special Training to General Intelligence," Educational Review, Vol. 36:38, 1908.

Hendrickson and Schroeder in their experiment based on Judd's basic method involving hitting a target submerged in water observed considerable variation within groups in the number of trials required by individuals to reach the selected criterion of success. They suggested as possible causes of such variation, "fluidity and variability of behavior when faced by a problem, a habit of verifying one's judgments, and the ability to formulate a general principle for oneself."[42] Though they obtained intelligence scores for the subjects as well as the scores from hitting the targets, they did not report a comparison of the two.

In a study of mathematical problem solving among fifth grade children in high, low, and average mental ability groups, Klausmeier and Loughlin[43] (1961) reported that the high IQ (Wechsler Intelligence Scale for Children) group was superior to the low not only in level of difficulty of problems solved but also in efficiency of method, persistence, and mode of attack. The problems required the subjects to designate the denominations of coins, or of coins and bills, required to total a specified amount of money. For each

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[42]G. Hendrickson and W. H. Schroeder, "Transfer of Training in Learning to Hit a Submerged Target," Journal of Educational Psychology, Vol. 32:212-213, 1941.

[43]H. J. Klausmeier and L. J. Loughlin, "Behavior During Problem Solving Among Children of Low, Average, and High Intelligence," Journal of Educational Psychology, Vol. 52:149-151, 1961.

problem the number of coins or coins and bills to be used was specified. Problems were graded for difficulty and administered to the appropriate ability group. For example, low ability subjects were assigned the problem of making seven cents with three coins. High ability children were assigned the problem of making $14.53 with sixteen bills and coins. The criterion for comparison was the ratio of the number of computations made to the least number required for the solution of the problem. They found that the high group disclosed significantly higher incidences of noting and correcting mistakes independently, of verifying solutions, and of using a logical approach. The low group disclosed significantly higher incidences of nonpersistence, of offering an incorrect solution, and of using a random approach. The findings of this study indicate that good learning habits are related to level of mental ability. If good learning habits are assumed to be favorable for transfer, then subjects of higher mental ability might be anticipated to demonstrate better transfer.

In the study of gifted children by Terman and Oden[44] measurements of specific types of ability have shown that high IQ and high specific ability tend to occur together.

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[44] L. M. Terman and M. H. Oden, The Gifted Child Grows Up. Genetic Studies of Genius, Vol. 4, 1947, pp. 27-29 and 358-372.

Exceptions mentioned were simple memory motor tasks with little intellectual involvement.[45, 46]

Memory itself is a necessary condition underlying transfer. Because it is, those conditions favorable to memory might also be favorable to transfer. One such condition is the level of mental ability. As has been the case for all scales based on the original Binet scales, memory was found by Terman and Merrill[47] in the construction of the Stanford-Binet Scale, 1937 Revision, to vary positively with mental age. They found this conclusion to be supported with various measurement media such as recall of digits in order or in reverse order, recall of sentences, recall of word meanings, and recall of visual patterns with transfer to motor patterns as with beads, blocks, and simple designs. However, there appears to be very little evidence concerning direct relationships between level of mental ability and transfer.

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[45] Ibid., pp. 27-29.

[46] J. W. Cox, "Some Experiments on Formal Training in the Acquisition of Skill," British Journal of Psychology, Vol. 24:85, 1933.

[47] L. M. Terman and M. A. Merrill, Measuring Intelligence, 1937, pp. 191-323.

Permanence of Transfer Effect

Katona[48] in his experiments with card tricks (see p. 26) found that a learned principle was retained longer than a memorized solution. He also observed that some of the subjects discovered the principle without instruction and that these subjects tended to retain the principle longer than those to whom the principle had been given.

English, Welborn, and Killian[49] in a study of retention of verbatim versus summarizing statements of verbal material found the latter were retained better over a four week period. Their findings suggest that broad meanings are retained better than specific statements. However, examination of the test items which they presented as examples of corresponding verbatim and paraphrased passages indicates that the process of paraphrasing resulted in improved readability. This study was concerned with retention rather than transfer. But its findings may help to explain findings in the study reported here relative to retention or persistence of transfer effect.

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[48]Katona, op. cit., pp. 44-50.

[49]H. B. English, E. L. Welborn, and C. D. Killian, "Studies in Substance Memorization," Journal of General Psychology, Vol. 11:233-260, 1934.

A study of retention of paired adjectives was reported by Greenberg and Underwood[50] (1950). Their study involved four different amounts of practice and three different lengths of recall interval. The recall intervals were ten minutes, five hours, and forty-eight hours. The investigators reported that for the two longer recall intervals success in recall of paired adjectives was inversely related to the amount of practice. Error intrusions from previous lists occurred with the longer intervals but not with the ten-minute interval. They concluded that proactive inhibition, a source of negative transfer, was a positive function of the number of prior lists learned and of the time between learning and measurement of recall.

The findings of these studies suggest that the relative permanence of transfer might be related to the method or circumstances of original learning. The retention of learned material is an essential factor in transfer. The studies by Katona and by English, Welborn and Killian indicate that retention of learned material is influenced by the method or circumstances of original learning. The study by Greenberg and Underwood suggests that negative transfer effects from prior learning of material similar

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[50] R. Greenberg and B. J. Underwood, "Retention as a Function of Stage of Practice," Journal of Experimental Psychology, Vol. 40:452-457, 1950.

but not identical to the material to be retained, increase with the amount of similar material learned and with the length of time of retention.

Transfer of coding principles

The cryptogram in our culture is a virtually universally recognized form of symbol activity. As such it is readily distinguished from other forms of communication.

R. Forgus and R. Schwartz[51] (1957) reported a study of retention and transfer of a code principle after initial learning by three different methods. The code principle was a systematic substitution of symbols for the letters of the alphabet. The letters were divided into groups of four. The letters within each group were represented by variations of the same symbol. The subjects were 39 female college students enrolled in a psychology course. One group was given the list of code symbols and a written explanation of the principle of the code. (Principles taught by this method are called given principles.) Another group was given the list of code symbols and asked to derive and describe the code principle. (Principles taught by this method are called derived principles.) The third group was given the list of code symbols in jumbled order so

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[51] R. H. Forgus and R. J. Schwartz, "Efficient Retention and Transfer as Affected by Learning Method," Journal of Psychology, Vol. 43:135-139, 1957.

that the principle could not easily be detected. This group was asked to memorize the list.

After one week the subjects were given a passage in the symbol code to translate as a test of recall. A transfer test was also administered to each subject. In this test the subjects were given a passage in a numerical code to translate. They were told that the new code system was slightly different from the one used before and were given a few key number symbols from which the code could be derived. The new code retained the principle of systematic substitution as in the former but divided the letters into groups of five instead of four and used two numbers to represent each letter. The given principle and derived principle learning groups were significantly superior to the memorization group on recall and transfer. No significant difference was found between the given principle and derived principle groups but their scores were so high that the experimenters thought the transfer test might have failed to detect any existing differences.

J. Warren[52] compared code substitutions rates (the rate at which the appropriate code letters or symbols were substituted for the letters of a message) for subjects

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[52]J. M. Warren, "Intertask Transfer in Code Substitution Learning," Journal of Genetic Psychology, Vol. 89: 65-66, 1956.

pretrained on one code and for subjects pretrained on sixteen codes. The subjects were college students. The codes included geometric symbols, letters, and nonsense syllables. The single code training group reached a significantly higher rate of accurate substitutions of letters or symbols but the two groups were not significantly different in transfer to other codes of the same type. He concluded that "the effects of adjustment to the learning situation were largely responsible for the intertask transfer found."[53]

The Haslerud and Meyers[54] (1958) study described earlier in this chapter used tests made up of twenty different coding principles. These coding principles constituted the material for their study of transfer.

No previous study was found which claimed or appeared to have constructed code principles from specifically identified and systematically applied code elements.

At the beginning of this chapter reference was made to several well known studies the findings of which indicated that the purported transfer values of formal discipline were not validated. Subsequent research concerning transfer of training has emphasized two basic theories of the

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[53] Ibid., p. 70.

[54] Haslerud and Meyers, op. cit., pp. 294-296.

nature of transfer. One of these theories was E. L. Thorndike's theory that transfer is dependent upon the existence of identical elements in the original learning situation and in the transfer situation. The other was C. H. Judd's theory that generalized principles and relationships are the essential content of transfer.

Studies of transfer of principles have shown that teaching two principles of solution of a problem produced more transfer than teaching just one principle. The learning of principles by either the given method or by the derived method has been shown to be superior on the whole in transfer value to memorized solutions or to practice alone. Comparisons of the transfer values of the given and derived methods of learning principles have been inconclusive. The study reported here was intended to provide further evidence concerning the transfer effects of given and derived principles.

Findings of several studies when examined together were thought to indicate the likelihood of a direct relationship between the amount of transfer of learning and the level of mental ability of the subjects. Evidence from certain studies of retention in verbal learning was thought to indicate the likelihood of a relationship between the method of original learning and the relative permanence

of transfer effects. This study was intended to provide evidence concerning such relationships.

The use of letter transposition and substitution codes in studies of transfer was found to be infrequent. No studies were found which provided a systematic method of development and use of coding principles. This study provides such a method.

CHAPTER III

PLAN OF THE INVESTIGATION

Organization

The experimental investigation involved in this study was an attempt to evaluate the influence of two variables, method of learning and level of academic ability, on the transfer of coding principles, such as "for each letter in the message substitute the second letter after it in the alphabet." A two by three factorial design provided the structural framework of the experiment. The two factor variable was method of original learning. The three factor variable was level of academic ability.

Three groups of subjects were formed to measure the experimental variables. These groups represented high, average, and low academic ability levels in equal numbers. Each ability group contained thirty subjects. Each subject learned coding principles by each method of learning in the same test. The use of a test as the initial learning experience provided measurements of the subject's initial success with each method of presentation. One method of learning required the subject to derive the code principle from an example, then to use it to encode another message.

The other method provided the example and the message to encode but also provided a written statement of the principle, such as the example given above. Every subject was, therefore, his own control for comparison of the two methods of learning. Subjects learned different code principles by the two methods of learning. Two forms of the initial learning test, equated for mean and variance, provided a control for differences in difficulty.

A control group of 58 subjects was equated for IQ mean, variance, and range to a group of 32 of the experimental group subjects. The first test was not administered to the control group. The control group attended their regular class while the first test was being administered. They were not aware they were to be tested until they took Test II.

Administration of the second test, requiring derivation of the coding principle for each item, to all subjects provided the transfer task. Comparisons between the control group and the equated group of experimental subjects provided evidence concerning the existence of transfer effect from the first test. The experimental subjects had had the learning experience of the first test to transfer to Test II. The control subjects had not had this experience. Otherwise the experiences of the subjects in the equated groups were considered to be of a similar nature concerning

experience with coding principles. The existence of a significant difference between the performances of the two equated groups on Test II would be assumed to be a result of transfer effect from the Test I experience of the experimental subjects. Comparison between experimental groups provided evidence concerning differential effects on coding test scores as related to level of academic ability. Comparisons between sets of items on Test II provided evidence concerning the differential effects of the original methods of learning of coding principles on Test I.

Test II was readministered to all subjects to assess the influence of retention and relearning on the relative permanence of transfer effects. The test was first readministered six days after its initial administration to provide measures of relative permanence over a short waiting period. The test was last administered fifty days after initial administration to provide measures of relative permanence after a somewhat longer waiting period.

Procedure

Forms A and B of the first test, the original learning task, were administered to subjects of the experimental group. The equivalent forms were randomly assigned to the subjects in approximately equal numbers within each experimental group. This provided a random assignment of the

effects of the two methods of learning. In one form a particular item was presented with the principle given for learning. In the other form the same item was presented without the statement of principle, therefore, the principle had to be derived to be learned. On each form of Test I the principle was given for each odd numbered item. The principle had to be derived for each even numbered item. For example: item 1, Form A, had the principle given. This same item appeared as item 2, Form B, without the statement of the principle. Similarly item 1, Form B, had the principle given. This same item appeared as item 2, Form A, without the statement of the principle. (See Appendix, p. 119.) By alternating the learning methods from item to item on each form, the learning methods were presented an equal number of times to each subject.

The tests were administered by three experienced testing counselors. The directions for administration were the same for all groups.[1] Subjects were tested in groups ranging in size from thirty to thirty-eight. For each test session in the series, all groups were tested on the same day.

Twenty-four hours after administration of the first test, the second test was administered to all subjects.

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[1]See Appendix, p. 118.

This test appeared in only one form. The same code principles that were used in the first were used in the second. The items were of the same type as those in the first except that the subject was required to derive the principle in each item. No principles were given. New messages were used so that the principle or a method of derivation could be transferred from the first test but memorized answers would be of little or no value. The Pearson Product-Moment Correlation Technique[2] was used to determine the correlation between Test I and Test II. Using the scores of the ninety experimental subjects, the correlation was found to be .90.

Briefly the tests were administered as follows:

Subject Groups	First Day of Testing	Testing After One Day	Testing After Six More Days	Testing After Forty-three More Days
Experimental High	Test I	Test II	Test II	Test II
Experimental Average	Test I	Test II	Test II	Test II
Experimental Low	Test I	Test II	Test II	Test II
Control	------	Test II	Test II	Test II

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[2]G. M. Smith, A Simplified Guide to Statistics, Revised and enlarged, 1946, p. 76.

The formula was:

$$r = \frac{\Sigma xy}{\sqrt{\Sigma x^2 \Sigma y^2}}$$

where r= correlation coefficient; x and y=the differences from the respective means of the scores on the test halves.

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Subjects

Subjects for this investigation were students in the ninth grade of a junior high school in a midwestern city with a population of 100,000. There were 500 students in the ninth grade. About ten of these students were enrolled in a special program for the educable mentally retarded and were not considered for inclusion in the study.

Of the remaining students the school had identified 32 for a special ability social studies class. The criteria for selection had been first that they had the highest IQ's in the grade, as measured by the California Short-Form Test of Mental Maturity (CTMM) and verified by the WISC. Second, they had scored a grade level or more above the norm on a standardized test of reading ability (several were used).

Thirty-five students had been identified by the school for special low ability social studies classes. The criteria for selection had been first failing work in a regular social studies class. Second, they had scored at least two grade levels below the norm in reading ability. Third, they had IQ's below 100 on the CTMM. These scores were verified with the WISC only if the case history suggested they might score low enough (70 IQ) to be eligible for the program for the mentally retarded.

The remainder of the students in the grade had been randomly assigned to one or another of twelve regular social studies classes of from 32 to 38 students each.

The high and low ability special classes and two regular classes were selected as the experimental groups for the study. This provided a sample stratified on the basis of academic ability. The CTMM IQ scores were used to divide the experimental subjects into three groups. The high ability level contained thirty subjects with IQ's in the range from 121 to 146. The average ability level contained thirty subjects with IQ's in the range from 91 to 121. The low ability level contained thirty subjects with IQ's in the range from 72 to 91. At the beginning of the study the number of experimental subjects was larger. Subjects were eliminated if they were absent from a scheduled test session and unable to take the missed test at the start of the next day. By this method 34 subjects, mostly of average or low ability, were eliminated from the experimental group.

Two other regular social studies classes were used as a source of control subjects. This group was composed of 58 subjects, after eliminating twenty because of absence from test sessions. This group was heavily weighted with average IQ's but, because new students were placed in regular classes, the IQ's of this group were in the range from 74

to 128. The numbers, means, standard deviations, and ranges of IQ's for each group are presented in Table I.

TABLE I Numbers, Means, Standard Deviations and Ranges of California Test of Mental Maturity-SF IQ's for All Groups

Group	N	M	σ	Range Low	Range High
Exper. High	30	129.0	7.5	121	146
Exper. Ave.	30	104.4	10.3	91	121
Exper. Low	30	84.9	6.0	72	91
Total	90				
Control	58	98.3	9.7	74	128
Exper. Equated	32	97.9	10.3	72	127

Origin of Instruments

Two instruments were required for this study. One instrument was required as an original learning experience. The other was required as the transfer experience. These instruments were the coding principles tests previously described.

Coding principles were chosen as the transfer media because coding is a virtually universally familiar symbol activity but is also quite dissimilar from other types of symbol activity. Code functions are concretely systematic. Items using various code principles, therefore, could be

devised to provide concrete measurable activity which could be varied in kind and difficulty. Such variation is possible because the parts of a code, the code elements, are manipulable in type and functional order. It was also hoped that the use of coding items in the instruments prepared for this experiment would tend to minimize unanticipated and uncontrolled proactive inhibitors from the previous experience of the subjects. The use of coding principles provides an unambiguous type of activity as opposed to the types of activity subject to ambiguity of word meaning, such as matching synonyms and antonyms to find the unmatched word in a group of five, which can damage the validity of findings in studies of verbal transfer.

Structure of Instruments

For the original learning task in their study, Haslerud and Meyers[3] used a test composed of items based on coding principles as employed in the "Come to London" code item in the Stanford-Binet Scale, 1937 Revision.[4] The present study also used that basic form. In this type of item a short message is presented first in English text and then in a particular code. A second message is presented only in English text. The subject is required to determine the

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[3]Haslerud and Meyers, op. cit., p. 294.

[4]Terman and Merrill, op. cit., pp. 120-121, 178, 184-185, 280-281, 398, 407.

code principle from the example of the first message, then to encode the second message in that code. (See Appendix, p. 119.)

Though recreational and serious coding has been based on the same basic elements used in the coding principles of this experiment, the method of their use was different. In the construction of the code principles two types of code elements were used, namely transposition and substitution elements. (Each specific function in a code principle is called a code element.) Transposition elements involved changes in the position of the letters relative to each other. For example, one element required the transposition of each pair of letters. The word "best" would be written in code as "ebts." Substitution elements involved removing a letter and putting another in its place. For example, one element required: "for each letter in the message substitute the next letter in the alphabet." "Apple" would be written in code as "bqqmf."

Limits of code element usage were established in advance to provide that once an element was understood it could be applied quickly and systematically throughout the appropriate message. Juxtapositional substitution and transposition are usually avoided in customary coding situations in order to render decoding more difficult. Such nearness of substitution and transposition was built

into all of the coding principles of this experiment in order to render them more readily solvable. For example, substitution elements were limited to alphabetic shifts, such as substituting B for A, which did not involve changes greater than three letters away in the alphabet. A positive three step shift would substitute D for A, E for B, F for C, etc. Long, time consuming shifts, such as substituting the second half of the alphabet for the first half, were considered inefficient because of the large amount of time required to demonstrate the principle once it has been learned. (See Appendix, p. 113.)

Nulls, letters with no meaning in the message, were used only under certain limitations. Nulls were used if they were placed after every letter or after every other letter in the encoded message. In addition nulls were required to be systematic. For example, a specific letter could be used as a null throughout, or letters could be used in alphabetic order, or vowels could be used in alphabetic order. An illustration of the use of vowels in alphabetic order as nulls alternating with letters of the message is "cat" written as "caaeti" (c<u>a</u>a<u>e</u>t<u>i</u>).

The transposition code elements were of three basic types: nulls, reversals, and other systematic changes in the order of the letters. Substitution code elements also were of three basic types: positive shifts (forward)

along the alphabet, for example substituting C for A and D for B; negative shifts (backward) along the alphabet, for example substituting Z for A and A for B; and a combination of positive and negative shifts.

There were six basic methods of applying these code elements. One method involved applying the element to each letter in turn throughout the message, such as the above substitution shifts. Another method required the use of two letters to represent one, such as substituting B and C for A. Another method involved applying an element within each word separately; for example, reversing the letters of each word. Another method required applying an element to letters in pairs, such as the transposition of pairs of letters as described above. Another method involved applying two elements to alternate letters. For example, one element might require the substitution of the next letter in the alphabet for every other letter in the message. The other element might require the substitution of the previous letter in the alphabet for the alternate letters. "Cattle" would be written in code as "dzusmd." Finally one method involved progressively changing an element from letter to letter in each word or progressively changing the element from word to word. For example, "In each word, for the first letter, substitute the first letter after it in the alphabet, for the second letter

substitute the second letter after it in the alphabet, etc." or "In the first word, for each letter substitute the letter after it in the alphabet; in the second word, for each letter substitute the second letter after it in the alphabet; etc."

Various combinations of these elements and the methods of using them provided two sample code principles and twenty-four test code principles of varying degrees of difficulty. The code principles are listed in the Appendix, p. 113. Code element usage has also been outlined in the Appendix, p. 116. Table II provides a blueprint of the combinations of code elements and the methods of their use. The principles are represented by their numbers from the code principle list. Some of the principles involved combinations of more than one code element or more than one method of application and were entered twice in the table to provide full description.

Test II used the same item form as Test I but no written statements of principles were given. Therefore, all principles had to be derived from the examples provided in the item. The principles numbered Y, 1, 3, 4, 5, 8, 15, 16, 17, 18, (see Appendix, p. 113), were variations of principles used by Haslerud and Meyers[5] in their study.[6]

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[5]Used by permission.

[6]Haslerud and Meyers, op. cit., pp. 293-298.

TABLE II Code Element Content and Method of Use for Each Code Principle by Number

Application or Method of Use	Code Elements: Systematic Transposition: Nulls	Systematic Transposition: Reversals	Order Change	Systematic Substitution by Alphabetic Shift: Pos.	Systematic Substitution by Alphabetic Shift: Neg.	Systematic Substitution by Alphabetic Shift: Both
To each letter in turn throughout the message	21*	1	5	3	6, 21*	
Two letters substituted for one	24*			20		11, 19*
Start at beginning of each word		8, 14*	12, 15	13, 18*	22*	
Application to letters in pairs		4, 23*		23*	24*	
Alternation of application of two elements	2, 9, 14*			7, 17	10	16, 19*
Progressive change of an element				13, 18*	22*	

*These principles were entered twice because they included more than one element or more than one method of use. (See Appendix, pp. 113-115, for a list of the principles.)

The remaining principles were developed for this study. The same principles were used in Test II as had been used in the two forms of Test I. The order of presentation of principles was varied systematically so that half of the principles were presented in the same order, within pairs, as they were in Form A, Test I, and the other half in the same order as in Form B, Test I. For example, items 1 and 2 in Form A provided the principles for items 1 and 2 in Test II. Next, items 3 and 4 in Form B provided the principles for items 3 and 4 in Test II. (See Appendix, pp. 119-126.)

To provide greater control of similarities and differences between items on the same test and between corresponding items on both tests, letter variations within the messages of an item were limited. Each message pair, including the message in the example and the message to be encoded within an item, was used for a block of four items. (See Appendix, p. 119.) This provided that not only the code principles but also the messages used would be identical for a pair of corresponding items. This provided control of message variables for comparing the two methods of original learning. Thus, for the two tests there were twelve message sets. The first message in each set, the Message A in the example of each item, contained three words. These first messages always included eleven

or twelve letters and these in turn always included eight or nine different letters. For example, one first message was "they have come." The second message in each set, the Message B to be encoded in each item, always contained four words. This was considered adequate length to disclose any error in understanding of the principle. The second message corresponding to the above example was "send four crews now." These second messages always included sixteen letters and these in turn always included six to eight different letters. Table III presents these data in tabular form with limits and ranges of variation indicated.

Items were arranged in spiral order in relation to anticipated difficulty. The difficulty varied from item to item sometimes toward greater difficulty, sometimes toward less but the general trend was one of increasing difficulty as the individual subject progressed through either test. Most of the subjects were unable to complete the tests, but the tests were considered to be more of the nature of power tests than speed tests because all but a few of the subjects seemed to have reached their limits before the end of the test session. At the same time Test I was administered to the experimental subjects it was also administered, in error, to 35 students not included in the study. This group was questioned about their reactions

TABLE III Length and Letter Variation of Code Item Messages

Message Set	Number of Items Using Set	Letters of Message A* Total	Letters of Message A* Number Different	Letters of Message B* Total	Letters of Message B* Number Different
Test I					
1	1-4	12	9	16	7
2	5-8	12	8	16	7
3	9-12	11	9	16	6
4	13-16	11	8	16	7
5	17-20	12	9	16	8
6	21-24	12	9	16	6
Test II					
7	1-4	12	9	16	7
8	5-8	12	9	16	8
9	9-12	12	9	16	6
10	13-16	12	8	16	6
11	17-20	12	8	16	7
12	21-24	12	8	16	7
Limits		11-12	8-9	16	6-8
Range		1	1	0	2

*Message A was used in the example in the item. Message B was the message to be encoded in the item.

to the test and the ensuing discussion was tape recorded. To the question, "Do you feel you could have improved your score if you had had more time?" the replies indicated that they felt that at best very little gain could be realized with additional time.

Subjects at all levels of ability and in all groups appeared highly motivated toward the tests. Many said that they felt they had done well. Though about one third of the low ability group appeared to lose interest in the third and fourth test sessions, most of the rest of this group worked diligently to the end and continued to express interest in the tests for months after the series had been completed. In the high ability group, interest was marked and there were numerous signs of continued interest during the periods between test sessions. Two of the subjects in the high ability group were known to have purchased copies of Zim's[7] book on codes after taking the second test for the first time but before completion of the series.

Reliability of the tests was determined statistically. Measurements obtained from the tests of the ninety experimental subjects were used for the analysis of reliability. The Test I, Form A, papers were rescored for the split half

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[7]H. S. Zim, Codes and Secret Writing, authorized abridgment, 1948.

technique. In each block of four items, the first two items were scored for one half of the test and the last two for the other half. The Pearson Product Moment Correlation Technique was used with adjustment for full length reliability by the Spearman-Brown formula.[8] The estimated coefficient of reliability thus obtained for the full test was .95. This was considered adequate for the purposes of the study.

The reliability of Test II was determined by the test-retest technique. Total scores were taken from the first and second administrations of this test for this analysis. The Pearson Product Moment Technique was used to obtain a coefficient of correlation. The coefficient obtained was .95. This was considered adequate also.

Validity of the test was not established statistically for lack of an adequate criterion. However, there is some evidence of construct validity. The two methods of learning,

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[8]Smith, op. cit., p. 79. The formula was:

$$r = \frac{2r_{\frac{1}{2}}}{1+r_{\frac{1}{2}}} \quad \text{where}$$

r=estimated correlation coefficient for the reliability of the full length test; $r_{\frac{1}{2}}$=correlation coefficient obtained with the Pearson Product Moment formula (in footnote 2, p. 54) for the reliability based on the split test.

by reading a statement of the principle and by deriving the principle from an example of a decoded message, appear to be the only ways by which the coding principles can be learned. Understanding of the coding principle appears to be essential for accurate encoding of the required message.

For comparisons of the effects of the two learning methods to be valid, all other variables must be controlled. The use of equated forms for Test I provided a means of such control. Each coding principle was used in identically the same item on both forms. On one form the written statement of the principle was added to provide the additional learning method. Alternating the learning methods from item to item on each form, so that each subject learned principles by both methods, provided a control for differences in subjects. Control of differences in the difficulty of the messages used in the items of both tests was provided. The number of letters and the variation of letters in each message were limited to provide equivalent messages for all items.

The item forms for Test II were the same as those used in Test I except for the omission of the written statements of coding principles. The same coding principles were used in both tests.

Tests were administered to subjects on the same days, in the same places, and according to the same detailed directions for administration (see Appendix, p. 118) by experienced examiners instructed in the administration of these tests. Further control for differences in examiners was provided by having the same examiner administer the tests to the subjects of both the high and low ability groups.

Administration

The tests were administered by three counselors who had primary responsibility for group testing in the school. Each had been educated at the graduate level in testing and the least experienced in group testing had had eight years of such experience. Each tester administered the tests to the same groups throughout the series. A copy of the directions for administration and copies of the tests and answers can be referred to in the Appendix, p. 118. A fifty minute class period was allowed for each session. At no point were the subjects informed that further testing would occur.

Hand scoring was time consuming but not difficult. Each answer was divided into four parts by natural divisions for words, or where these were rendered meaningless by the nature of the code principle, by division into groups of

four letters each. If all letters were correct for a given group, that group was worth one point. Each item was worth four points and the maximum possible score for any test was 96. A perfect score of 96 was made only once, by a girl in the high ability group on the third administration of Test II. Zero scores occurred four times in the entire test series so the range of difficulty appears to have been adequate. The chance factor appears to have been adequately minimized by the nature of the items. The probability of a particular subject obtaining even one point of the 96 possible, by guessing, is about one in 5,000.[9]

Pilot Study

Prior to the beginning of the experimental test series the test form itself was tested. Test I, Form A, was administered twice for this purpose. Form A was administered first to three subjects in another city to identify any major weaknesses. The interpretation of "odd and even numbered letters" was found to be ambiguous in the statements of several principles. The form was revised so that

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[9]The probability of all four letters in a unit being correctly selected by chance is $(1/26)^4$. There were 96 units in each test. The probability of getting one correct unit by chance was therefore $96(1/26)^4 = .0002$.

after each statement of a principle where it would be appropriate, an explanatory statement was placed in parentheses as follows: "Count straight through the message to determine which letters are odd and which are even."

The test was then administered to 26 subjects in a third city. These subjects had a wide range of academic ability as measured on the California Short-Form Test of Mental Maturity. This provided an additional check on the spread of difficulty of the test. After minor revision the tests were prepared in their final form.

CHAPTER IV

PRESENTATION AND INTERPRETATION OF THE DATA

Preliminary Analysis

The organization of the study as described in Chapter III provided for three types of comparisons. First, the performances of the control group and the equated experimental group were compared. This comparison involved the total scores of the subjects from each administration of Test II. Comparison was made of scores from each administration to determine if the experimental group scores were significantly different from control group scores. Such a difference would reflect the effect of the Test I experience of the experimental subjects which was not provided for the control subjects. A difference in favor of the experimental subjects would indicate positive transfer from Test I. Continued demonstration of such a difference on the second and third administrations of Test II would indicate relative permanence of the transfer effect.

Second, performance of experimental subjects on given and derived principles was compared on Test I and for

administrations of Test II. Given principle scores and derived principle scores were obtained from each test for this comparison. These comparisons provided evidence not only as to whether a transfer differential existed favoring one learning method over the other but also whether such a differential, if found, persisted to subsequent testing.

Third, performances of subjects in the three experimental groups were compared for evidence of influence of level of academic ability on transfer of coding principles. Given and derived principles were compared to examine possible interaction of method of learning and level of ability. Comparisons were also made between levels of ability.

The scores obtained from Forms A and B of Test I as administered to the experimental groups were compared statistically to determine whether the combinations of given and derived types of items had been adequately equated for difficulty. The results of this comparison are presented in Table IV. Using the low critical ratio as evidence that the forms were equivalent, scores obtained from both forms were combined for the statistical analyses of the study.

TABLE IV Comparison of Scores of the Experimental Subjects on Forms A and B of Test I

Form	N	Mean	σ	σM	t	Sig.
A	45	35.6	23.1	3.5	.368	73%
B	45	37.4	21.5	3.2		

Methods of Analysis

For all statistical comparisons to be evaluated in the study, the 5 per cent level of confidence was selected as the minimum acceptable level of significance of differences.

Comparisons of differences in results obtained from the equated control and experimental groups on Test II were based on critical ratios obtained with the t test described by Smith.[1] This test was also used for comparisons in

[1] Smith, op. cit., pp. 30, 55-58. The formula was as follows:

N_1 = the number of subjects in group
X^1 = the difference between a particular score and the mean
σM_1 = standard error of the mean
$\sigma M_1 - M_2$ = standard error of the difference between the means
M_1 = Mean
t = critical ratio

$$t = \frac{M_1 - M_2}{\sigma M_1 - M_2} \qquad \sigma M_1 - M_2 = \sqrt{\sigma^2 M_1 + \sigma^2 M_2} \qquad \sigma M_1 = \frac{\sigma 1}{\sqrt{N_1 - 1}} \qquad \sigma 1 = \sqrt{\frac{\Sigma X_2}{N_1}}$$

the preliminary analysis.

Comparisons between methods of learning the principles (given and derived) and comparisons between levels of mental ability (low, average, and high) for the experimental subjects were based on critical ratios obtained by the method of analysis of variance described by Dixon and Massey[2] and by

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[2]W. J. Dixon and F. J. Massey, Jr., Introduction to Statistical Analysis, pp. 163-167. The formulas for sums of squares (SS) were as follows:

T=total
N=number of subjects
C^1=correction factor
Y=individual subject score for one method
ds=degrees of freedom
V=mean square
F=critical ratio

Subscripts r=rows, c=columns, g=groups, t=total

$$\text{Methods SS} = \sum \frac{Tr}{Nr} - C^1 \qquad C = \frac{(\sum Y)^2}{N_T}$$

$$\text{Levels SS} = \sum \frac{T_c}{N_c} - C^1$$

$$\text{Subtotal SS} = \sum \frac{T_g}{N_g} - C^1$$

Interaction SS = Subtotal SS-Methods SS-Levels SS

Total SS = $\sum Y^2 - C^1$ Error SS=Total SS-Subtotal SS

$$V = \frac{SS}{df}$$

$F = \frac{V \text{ of methods, Levels, or Interaction}}{V \text{ of error}}$

Ray.[3] With two methods of learning and three levels of mental ability each analysis involved relationships among six subgroups. Comparisons between pairs of these groups could not be made with the t test because it assumes a limit of one degree of freedom. For such comparisons a method of individual comparisons for factorial designs was found appropriate. This involved comparison of the range of means to the within-groups or error sum of squares.[4] Appropriate tables were found in Hodgman[5] and in Dixon and Massey.[6]

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[3]W. S. Ray, An Introduction to Experimental Design, Ch. 6 and 11.

[4]Dixon and Massey, op. cit., pp. 169-171. The formula was as follows:

a=assigned coefficients for group means; $\sum a=0$;
$\sum$ of positive a's=1
M=mean of group
q_p=percentile at a given degree of freedom of the standard deviation, number of means, and cumulative proportion (p), for the range of means divided by the standard deviation
N=number in a group
$S=\sqrt{\text{error V}}$

$$\sum aM \pm q_p \frac{S}{\sqrt{N}}$$

This provides the confidence limits for the comparisons involved.

[5]C. D. Hodgman, Mathematical Tables.

[6]Dixon and Massey, op. cit.

Main Analysis

Test I was administered to the experimental subjects as the initial learning task. The means and standard deviations obtained for each ability level on Test I are given in Table V. The results of the analysis of variance of these scores are summarized in Table VI. As indicated,

TABLE V Test I Means and Standard Deviations of Experimental Groups for Methods of Learning and Ability Levels

Ability Level	Method of Learning: Given N	Given Mean	Given σ	Derived N	Derived Mean	Derived σ
Low	30	10.83	6.98	30	7.57	5.85
Average	30	19.83	9.09	30	15.47	8.90
High	30	32.10	7.50	30	27.53	8.55

TABLE VI Test I Analysis of Variance of Experimental Groups

Component of Variability	SS	df	V	F	Sig.*
Methods	744	1	744	11.57	.1%
Levels	12,888	2	6,444	100.24	.1%
Interaction	16	2	8	.122	90%
Error	11,186	174	64		
Total	24,834	179			

*Significance of chance less than .1% is indicated as .1%.

the critical ratios for differences between methods and for differences between levels were large enough to be considered highly significant. Individual comparisons of pairs of means, however, indicated that at any one level of ability the difference between the mean for given principles and the mean for derived principles (hereafter G and D respectively) was not large enough to be considered significant at the 5 per cent level of confidence. Therefore, it could be stated that G and D methods were not found to be significantly different at any one level of ability on Test I but that the over-all trend for G scores to be higher than D scores appeared very significant.

All comparisons of differences between pairs of groups with the members of the pair at different levels of mental ability were found to be significant at the 1 per cent level of confidence. These comparisons each in turn indicated that the higher level of ability obtained the higher scores.

Test II-1 (Test II, first administration) was administered to all subjects to provide evidence for the evaluation of transfer. This test was administered twenty-four hours after Test I. Means and standard deviations for Test II-1 are given in Table VII. The analysis of variance is summarized in Table VIII.

TABLE VII Test II-1 Means and Standard Deviations of Experimental Groups

Ability Level	Method of Learning: Given N	Given Mean	Given σ	Derived N	Derived Mean	Derived σ
Low	30	12.63	6.75	30	12.00	7.07
Average	30	22.93	8.88	30	23.77	8.37
High	30	34.67	7.22	30	34.27	8.17

TABLE VIII Test II-1 Analysis of Variance of Experimental Groups

Component of Variability	SS	df	V	F	Sig.*
Methods	.75	1	.75	.012	95%
Levels	14,717.88	2	7,358.94	117.62	.1%
Interaction	19.47	2	9.73	.156	90%
Error	10,885.90	174	62.56		
Total	25,626.31	179			

*Significance of chance less than .1% is indicated as .1%.

Again each level of mental ability measured significantly different from each of the others in ascending order and at the 1 per cent level of confidence. However, the difference between methods of learning was below the selected level of significance.

Tests I and II were described in Chapter III. Test I, the learning test, was prepared in two equivalent forms. Each form contained alternating given and derived items. Twelve different coding principles were presented in the derived items. Each item required that a coding principle be derived from an encoded message. Another set of twelve different coding principles was presented in the given items. In these items a written statement of the principle was given with the encoded message. In both types of items the subject was required to demonstrate knowledge of the code principle by encoding a second message. Test II, the transfer test, presented the same twenty-four code principles in items of the derived type.

The Test II-1 scores themselves do not prove that transfer from Test I influenced the scores of Test II-1. In order to determine whether transfer did in fact occur, the scores of the control group on Test II-1 were compared to the scores of the equated experimental group on Test II-1 since this group of experimental subjects and the control group had been equated on IQ mean, range, and variance.

The difference between these groups was the experience the experimental group had in taking Test I. The data from this comparison are given in Table IX. The data for similar comparisons after each of the subsequent administrations of Test II are also given in the same table.

TABLE IX Comparison of Test II Scores of the Control and Equated Experimental Groups

Group	N	Mean	σ	σ_M	t	Sig.*
Test II-1						
Equated Exper.	32	40.16	16.25	2.92	5.06	.1%
Control	58	23.28	12.17	1.61		
Test II-2 (Six days after Test II-1)						
Equated Exper.	32	45.37	17.27	3.10	3.08	.3%
Control	58	33.65	16.50	2.19		
Test II-3 (Forty-nine days after Test II-1)						
Equated Exper.	32	45.25	17.76	3.19	1.89	5.9%
Control	58	37.64	18.60	2.46		

*Significance of chance less than .1% is indicated as .1%.

On the first administration of Test II-1 the experimental subjects obtained higher scores on the whole than those obtained by the control group. The difference was significant

at the .1% level of confidence. After six days the difference between these groups was smaller but still significant. After another 43 days the difference had narrowed to the extent that it was on the borderline of significance at 5.9 per cent.

The practice effect of Test I may be roughly equivalent to that of Test II-1 and therefore be a primary factor of transfer. To determine whether on this basis practice effect might be of significance, appropriate scores were compared. The scores obtained by the experimental group on Test II-1 and the scores obtained by the control group on Test II-2 were considered to have been preceded by about equal amounts of practice since the experimental group had taken Test I before Test II-1 and the control group had taken Test II-1 before taking Test II-2. Also, the scores obtained by the experimental group on Test II-2 were considered to have been preceded by about the same amount of practice as the scores obtained by the control group on Test II-3. The data of these comparisons are given in Table X. In both comparisons the difference was found to be near significance. The transfer indicated by the comparisons of the equated experimental and control groups (Table IX) does not appear to have been a result of differences in the amount of practice. Apparently then the transfer value of Test I for performance on Test II-1 was

TABLE X Comparison of Test II Scores of the Control Group with the Equated Experimental Group After Equivalent Amounts of Practice

Group and Test	N	Mean	σ	σ_M	t	Sig.
Exp. II-1	32	40.16	16.25	2.92	1.79	7.3%
Cont. II-2	58	33.65	16.50	2.19		
Exp. II-2	32	45.37	17.27	3.10	1.95	5.1%
Cont. II-3	58	37.64	18.60	2.46		

not a result of the additional practice. The methods of learning in Test I appear to be the source of transfer effect.

The means and standard deviations of the differences between the scores obtained on Test I and Test II-1 by each of the experimental groups for each level of ability are given in Table XI. The data from an analysis of variance of these differences are given in Table XII. A significant difference was found between the mean differences for G and D scores. The correlation between Test I and Test II has been found to be .90. However, there is a danger implicit in any comparison of scores from different tests no matter how similar those tests may be. Such

TABLE XI Means and Standard Deviations of Differences of Given and Derived Scores Between Test I and Test II-1 for Experimental Groups

Ability Level	N	Method of Learning: Given Mean Difference	Given σ_D*	Derived Mean Difference	Derived σ_D*	Difference of Mean Differences
Low	30	1.80	5.59	4.43	4.98	2.63
Average	30	3.10	7.34	8.30	6.44	5.20
High	30	2.77	6.48	6.73	5.41	3.96

*Standard deviation of the differences.

TABLE XII Analysis of Variance of Differences Between Test I and Test II-1 Given and Derived Scores of Experimental Groups

Component of Variability	SS	df	V	F	Sig.*
Methods	696.29	1	696.29	18.175	.1%
Levels	204.97	2	102.48	2.675	10%
Interaction	49.33	2	24.66	.644	54%
Error	6,666.41	174	38.31		
Total	7,617.00	179			

*Significance of chance less than .1% is indicated as .1%.

differences are not controlled for differences between the tests. Any difference between the scores obtained by an individual subject on two different tests could as readily be attributed to differences contained in the tests themselves as to transfer of learning. It is worthy of note that the mean differences of G and D scores at each level of ability culminating in apparently equivalent G and D scores on Test II-1 (Table VII) could have been the result of combination of transfer effects from both G and D items in Test I to each item in Test II-1. This might occur if code elements were learned or if a general principle or method of decoding was transferred rather than specific code principles.

Comparison of the mean difference obtained by one level of ability to the mean difference obtained by another level of ability was controlled for test differences, however, because both tests were common factors in each difference of scores. The comparisons between levels of ability, therefore, may have meaning. Neither the critical ratio for levels of ability nor the individual comparisons for pairs of groups at different levels of ability disclosed any differences which were significant. The G and D score difference of means at the average level of ability and the critical ratio for levels of ability both approached significance. It seems prudent to recognize that this might occur by chance in a series of comparisons.

Use of the same subjects for all three administrations of Test II involved additional learning as well as forgetting. It was deemed advisable to subject each administration separately to analysis. This method provided a cross sectional view of the effects existing at various stages of the experiment.

Six days after the first administration of Test II this test was administered to the same subjects again. The means and standard deviations derived from the scores of Test II-2 are given in Table XIII. The data obtained from the analysis of variance are given in Table XIV. The difference attributable to method of learning coding principles remained virtually nonexistent. The difference

TABLE XIII Test II-2 Means and Standard Deviations of Experimental Groups

Ability Level	N	Method of Learning: Given Mean	Given σ	Derived Mean	Derived σ
Low	30	14.13	8.13	14.40	8.09
Average	30	25.40	8.51	26.50	10.39
High	30	37.63	6.38	37.27	6.29

TABLE XIV Test II-2 Analysis of Variance of Experimental Groups

Component of Variability	SS	df	V	F	Sig.*
Methods	5.00	1	5.00	.074	81%
Levels	16,124.57	2	8,062.28	119.77	.1%
Interaction	15.36	2	7.68	.114	90%
Error	11,713.07	174	67.32		
Total	27,858.00	179			

*Significance of chance less than .1% is indicated as .1%.

attributable to difference in level of mental ability remained great and was significant at a level of confidence far beyond the minimum limit selected for this experiment. The critical ratio required for significance at the 5 per cent level of confidence for levels of mental ability was 3.00. For the 1 per cent level a critical ratio of 4.61 was required. The critical ratio obtained was 119.77.

Forty-three days after the administration of Test II-2, Test II was administered to the same subjects for the third and last time. The means and standard deviations derived from the scores obtained by the experimental groups for each level of ability on Test II-3 are given in Table XV. The data obtained from the analysis of variance of these scores are summarized in Table XVI. The effects of methods

TABLE XV Test II-3 Means and Standard Deviations of Experimental Groups

Ability Levels	N	Method of Learning: Given Mean	Given σ	Derived Mean	Derived σ
Low	30	14.97	8.36	14.70	7.52
Average	30	27.00	9.46	26.47	9.49
High	30	38.07	6.23	37.67	6.93

TABLE XVI Test II-3 Analysis of Variance of Experimental Groups

Component of Variance	SS	df	V	F	Sig.*
Methods	10.00	1	10.00	.166	75%
Levels	15,926.00	2	7,963.00	132.5	.1%
Interaction	293.23	2	146.61	2.439	10%
Error	10,456.77	174	60.10		
Total	26,686.00	179			

*Significance of chance less than .1% is indicated as .1%.

of learning appeared again at this point in the experiment to be virtually equal. Effects of differences in levels of mental ability appeared even more significant than before. Individual comparisons of pairs of groups with each member of the pair at a different level of mental ability were all

found to be significant at the 1 per cent level of confidence. Each comparison of a pair of groups with different learning methods at the same level of ability indicated no significant difference.

CHAPTER V

RESULTS OF THE INVESTIGATION

The scores from the transfer test (Test II-1) of the control subjects were compared to those of the equivalent experimental group. The only known pertinent difference between these groups was the experience the experimental group had acquired from the learning test (Test I). The comparison of scores on Test II-1 for these groups, given in Table IX, p. 82, indicated that the experimental group scored significantly higher than the control group and, therefore, did benefit from transfer from the learning test. This finding indicated that there was transfer to be examined relative to the hypotheses of the experiment.

Hypothesis 1 stated, "More able subjects will transfer derived principles better than given principles." The more able subjects scored higher on given principles in the learning test than on derived principles. However, they obtained nearly equal scores for given and derived principles on the transfer test. (See Table VII, p. 80, and Table VIII, p. 80.) Hypothesis 1, therefore, was not supported.

Hypothesis 2 stated, "Less able subjects will transfer given principles better than derived principles." As

indicated for the high ability group the scores of the low ability group for given and derived principles on the transfer test were not significantly different. Hypothesis 2 also was not supported.

Hypothesis 3 stated, "More able subjects will transfer better than average ability subjects and average ability subjects will transfer better than less able subjects." The influence of the difference in initial ability persisted through each of the administrations of the transfer test. (See Tables VII, p. 80, XIII, p. 87, and XV, p. 89.) This finding suggests that the influence of the differences in level of ability upon the coding test scores persisted throughout the experiment.

Comparison of the score of a subject on the learning test to his score on the transfer test has been indicated to be of questionable significance because Test I and Test II-1 though equated (r=.90) were not identical. However, comparison of the difference between scores on Test I and Test II-1 obtained by one subject to the difference obtained by another subject was controlled for test differences because both tests were common factors in each difference of means. As indicated in Chapter IV, no significant differences were found between mean differences for each level of ability. Hypothesis 3, therefore, was not supported. This finding suggests that the transfer value of performance on Test I for performance on Test II-1

was equivalent for all three levels of ability. This finding of equivalent increments corresponds with data in the study reported by Hendrickson and Schroeder[1] though their interpretation stated that this indicated a different percentage of increase from the first testing and, therefore, different transfer. On the basis of this interpretation their data favored given principles over derived principles.

Comparison of the scores on Test II-1 corresponding to each experimental method of original learning provided further evidence concerning transfer. The difference between given and derived scores on Test II-1 was not significant. (See Tables VII, p. 80, VIII, p. 80.) This equivalence of scores on Test II-1 corresponded with similar findings in one of the studies by Craig[2] and in the study by Haslerud and Meyers.[3] Craig stated only that this equivalence constituted equivalent performance on the transfer test. Haslerud and Meyers noted that the scores for derived principles were lower on the learning test than the scores for given principles. This, they said, indicated that the derived principles had gained more in score to reach equivalence with the scores for given principles on

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[1]Hendrickson and Schroeder, loc. cit.

[2]Craig (1956), loc. cit.

[3]Haslerud and Meyers, pp. 295-6.

the transfer test. They interpreted this as indicating greater transfer from the learning test to the transfer test for derived principles. Haslerud and Meyers noted that because each subject was his own control for comparison of given and derived scores, it was considered legitimate to use the subtraction method to find the standard error of the difference for paired observations. The same conditions existed for paired observations of scores from Test I and Test II-1 in this study. A comparison of the appropriate data in this study was described in Chapter IV.

The differences from Test I to Test II-1 appeared to favor the derived scores. This finding compared quite favorably with the data reported by Haslerud and Meyers and could be construed to support their contention that this comparison indicated superior transfer for the derived method of learning coding principles. As indicated in Chapter IV, however, there are other plausible explanations for this phenomenon. The differences in means on the learning test for the given and derived methods of learning may be a result of differences in the difficulty of the two methods. The nearly equal means for given and derived principles on Test II-1, the transfer test, may indicate that the transfer values of the two methods of learning are equivalent and independent of the difficulty of the two methods. Another possibility is that this equivalence of

means may be a result of transfer of a principle or method of decoding instead of specific coding principles. Another possibility is the transfer of elements of code structure rather than transfer of specific coding principles. Transfer of code elements would benefit both given and derived principles because the various types of elements were used in the construction of both sets of principles and because each specific principle was used in both sets depending upon the Test I form used. The equivalance of means on Test II-1 for given and derived principles suggests equivalence of transfer value from Test I for the two experimental learning methods.

Further administrations of Test II to the same subjects provided evidence concerning the relative permanence of the transfer effects. Comparison of the scores attained by the equated experimental and control groups disclosed evidence that the transfer advantage the equated group of experimental subjects obtained from Test I had diminished after one week but remained significant at the .3 per cent level of confidence. After seven weeks the advantage had diminished to borderline significance at the 5.9 per cent level of confidence. (See Table IX, p. 82.)

The next two hypotheses were as follows:

Hypothesis 4: With more able subjects the transfer effects of derived principles will be more permanent than those of given principles.

Hypothesis 5: With less able subjects the transfer effects of given principles will be more permanent than those of derived principles.

The difference in scores attributable to difference in level of ability remained significant throughout the testing. (See Tables VIII, p. 80, XIV, p. 88, and XVI, p. 89.) The differences attributable to method of learning were not found to be significant on any of the administrations of Test II. Hypotheses 4 and 5 failed of support in that no differences attributable to methods of learning were found to be significant.

The important finding in this analysis appears to be that transfer effects were not specific to the coding principles learned by one method or the other but were of equivalent value for the relearning of both sets of coding principles. This finding suggests that it was not the coding principles themselves that were transferred but rather other factors which facilitated the relearning of coding principles. These factors may have been familiarity with the structural elements of the coding principles or a general principle of analysis of coded messages, or other aids to the decoding process.

Hypothesis 6 stated, "Transfer effects will be more permanent with more able subjects than with average ability subjects and will be more permanent with average ability

subjects than with less able subjects." Subjects at all three ability levels were administered the same tests at the same times. The data from Tests II-1, II-2, and II-3 were examined relative to this hypothesis. (See Tables VII, p. 80; XIII, p. 87, and XV, p. 89.) The percentages of gains after one week and after seven weeks for each level of ability were as follows:

	Low	Average	High
Test II-1 to II-2	16%	11%	9%
Test II-1 to II-3	20%	14%	10%

Comparisons of these gains are not clear cut. The lower ability subjects made their gains with easier code principles. Higher ability subjects might be anticipated to relearn more readily than lower ability subjects. The data indicate that relative permanence of transfer effects existed for all three groups and that no distinct advantage in permanence of transfer effects of one ability level over another is indicated. Hypothesis 6, therefore, was not supported.

The performance of the equated experimental group on Test II-1 after taking Test I was found to be significantly superior to the performance of the control group on Test II-1 with no prior experience in taking Test I. This was considered an adequate indication that transfer effect from the experience on Test I caused a significant increase in scores

obtained in Test II-1 by the experimental subjects. In addition the performance of the equated experimental group on Test II-1 (preceded by experience on Test I) was found to be superior to the performance of the control group on Test II-2 (preceded by experience on Test II-1) though these performances were considered to have been preceded by comparable amounts of practice. After another administration of Test II to both groups, the superiority of performance of the experimental group was even more significant.

This study found significant evidence of transfer from Test I to Test II-1. The evidence indicated that the transfer effects were not attributable to differences in the amount of practice on the coding tests. Similar amounts of transfer effect were found at all three levels of ability. The study found that these transfer effects were of equivalent relative permanence for all three levels of ability.

The given and derived methods of learning appear to have been of equal transfer effect from Test I to Test II. These methods of learning may, however, have been of unequal transfer value for code elements. Knowledge of structural elements, common to codes in both sets of principles, may have been transferred rather than knowledge of specific coding principles.

CHAPTER VI

SUMMARY AND CONCLUSIONS

Summary

A study of transfer of coding principles was conducted to compare the transfer effects of two methods of learning. In one learning method the subject was required to learn the principle by deriving it through study of its application to a message. In the other learning method the subject was given a written functional statement of the code principle with the code item.

The study also examined the influence of the level of academic ability upon transfer. For this purpose the subjects, ninth grade students, were assigned to low, average, and high experimental groups according to their IQ's as measured with a group test. The study also obtained evidence concerning the relative permanence of the transfer effects.

Initial learning was provided in a coding test prepared in two forms to provide control for differences in difficulty of items presented with and without the written statements of the coding principle. The transfer test was made up of items of the same type with the same

coding principles but with no given statements of principles and with new messages for decoding and encoding.

Comparison of scores for equated groups of 32 experimental subjects and 58 control subjects indicated that transfer from Test I to Test II-1 was significant in amount and that this significance of transfer advantage decreased by the end of one week and was of only borderline significance at the end of seven weeks. It was found that this transfer advantage could not be attributed to the difference in amount of practice.

Comparison of the scores earned by the thirty subjects in each of the three experimental groups disclosed that differences in level of ability corresponded with significant differences in coding test scores. The differences in scores attributable to difference in level of mental ability remained significant throughout the sequence of tests.

Comparison of the scores earned by the ninety experimental subjects on principles learned by the derived method to those learned by the given method disclosed no significant differences on the three administrations of Test II, the transfer test.

Conclusions

Examination of the scores obtained with Test I has disclosed that an item in which the principle is given is

significantly easier than an item in which the principle has to be derived. Comparison of subsequent scores on the three administrations of Test II to the subjects at the three levels of ability disclosed no significant differences attributable to initial method of learning. It appears probable that transfer effects were not related to the code principles as such but rather in a more generalized way to the solution of code principles of this type. The transfer found appeared to benefit equally both sets of code principles regardless of the method of original learning.

Data in this study indicated that transfer effects from Test I diminished in significance from Test II-1 to Test II-2 and to Test II-3. Differences of scores attributable to the level of mental ability of the subjects were significant and tended to persist. Subjects at three levels of mental ability made similar gains in transfer from one coding principle test to another. Relatively similar permanence of these transfer effects was demonstrated for all three levels of ability over a period of seven weeks. It does not follow that all levels of ability benefited equally from these gains. The higher levels of ability made their gains with more difficult principles.

Further research with matched groups or other techniques designed to separate the effects of the two methods of learning appears desirable. Also further research might attempt to determine whether transfer of the type disclosed in this study is based on knowledge of specific types of structural code elements or on a general principle or method of solution of coding problems or on some other basis. Answers to such questions may further clarify the apparent disagreement between studies of given and derived principles and may suggest the ways transfer occurs with other verbal media.

Though the given and derived methods of learning were found to be of equivalent transfer effect for coding principles in this study, they may not have been equivalent in transfer effect for code elements within the code principles. Knowledge of structural code elements may have been transferred rather than knowledge of specific code principles. Further research might compare the transfer value of given and derived coding principles using matched groups of subjects. For this purpose Test I might be rewritten as two tests. One group of subjects could be required to derive all of the principles on one test. The other group could be given the written statements of the principles in the other test. Test II could then be administered to both groups for comparison of transfer

effects. In a similar manner the transfer value of given or derived principles might be compared with the transfer value of given and derived principles together.

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APPENDIX

CODE PRINCIPLES

Sample Y.* Write the words in reverse order.
Z. Write each letter twice.

1.* Write the letters of the message in reverse order.

2. Alternate the letters of the message with the letter "E".

3.* For each letter in the message substitute the letter that follows it in the alphabet.

4.* Divide the message into pairs of letters; reverse the letters in each pair.

5.* Write the odd numbered letters, then write the even numbered letters. (Count straight through the message to determine which letters are odd and which are even.)

6. For each letter in the message substitute the letter that is before it in the alphabet.

7. For each odd numbered letter substitute the first letter following it in the alphabet; for each even numbered letter substitute the second letter following it in the alphabet. (Count straight through the message to determine which letters are odd and which are even.)

8.* Write the letters of each word in reverse order.

9. Alternate the letters of the message with the letters of the alphabet in order starting with "A".

10. For each odd numbered letter substitute the first letter before it in the alphabet; for each even numbered letter substitute the second letter before it in the alphabet. (Count straight through the message to determine which letters are odd and which are even.)

11. For each letter substitute both the letter before it and the letter after it in the alphabet.

12. Write the first letter of each word, then write the second letter of each word, etc.

13. In each word for the first letter substitute the first letter after it in the alphabet, for the second letter substitute the second letter after it in the alphabet, etc.

14. Write the letters of each word in reverse order and alternate with the letters of the alphabet in order starting with "M".

15.* Write the last letter of each word, then the second from last letter of each word, etc.

16.* For each odd numbered letter substitute the letter after it in the alphabet; for each even numbered letter substitute the letter before it in the alphabet. (Count straight through the message to determine which letters are odd and which are even.)

17.* Write odd numbered letters as they are; for each even numbered letter substitute the letter after it in the alphabet. (Count straight through the message to determine which letters are odd and which are even.)

18.* In the first word, for each letter substitute the letter after it in the alphabet; in the second word, for each letter substitute the second letter after it in the alphabet; etc.

19. For each odd numbered letter substitute the first and second letters after it in the alphabet; for each even numbered letter substitute the second and first letters before it in the alphabet. (Count straight through the message to determine which letters are odd and which are even.)

20. For each letter substitute the second and first letters after it in the alphabet.

21. For each letter substitute the second letter before it in the alphabet; alternate with the letters of the alphabet in order beginning with "F".

22. In each word for the first odd numbered letter substitute the first letter before it in the alphabet, for the second odd numbered letter substitute the second letter before it in the alphabet, etc.; write the even numbered letters in each word as they are in the message. (Count straight through each word to determine which letters are odd and which are even.)

23. Reverse the letters in each pair, then for each substitute the second letter after it in the alphabet.

24. For each letter substitute the first and third letters before it in the alphabet, alternate these pairs with the vowels in alphabetic order.

*Variations of codes used by Haslerud and Meyers. Used by permission.

CODE ELEMENT USAGE

I. Transposition

A. Systematic nulls

1. Alternate letters of message with letters of alphabet in order (9)*

2. Alternate letters of message with one given letter (2)

B. Reversal

1. Message by letters (1)

2. Letters in pairs (4)

3. Letters in words (8)

C. Systematic mixing

1. First letter of each word, etc. (12)

2. Last letter of each word, etc. (15)

3. All odd then all even numbered letters in order counting through the message (5)

4. Reversals of letters in words plus systematic nulls (14)

II. Substitution

A. Simple alphabetical shift: add 1 (3); sub. 1 (6)

B. Alternating shift: add 1, 2 (7); sub. 1, 2 (10); sub. 1, add 1 (16)

C. Progressive shift

1. First letter of each word start shift: add 1, 2, etc.(13)

*Number in parentheses at end of each description refers to principle in which this element was used.

2. Each word given different shift interval in order (18)

D. Double shift: add 1 & sub. 1 (11); add 2 & 1 (20)

E. Alternating double shift: add 1 & 2, sub. 2 & 1 (19)

F. Alternating shift with true letter: 0, add 1 (17)

G. Alternating true with negative progressive shift starting with 1 at the beginning of each word (22)

III. Combination of transposition and substitution elements

A. Simple shift with systematic nulls (21)

B. Reverse letters in pairs and shift add 2 (23)

C. Double negative shift with systematic vowel nulls between pairs (24)

CRYPTANALYSIS TEST

INSTRUCTIONS TO EXAMINER

I. Preparation for administering the test

A. Become familiar with the test and these instructions

B. Have a supply of tests equal to the number of subjects to be tested, plus a copy for the examiner, plus a few extra copies to provide for miscount, damaged copies, or unexpected subjects.

II. Administration of the test

A. Pass out the test copies, asking the subjects to fill the blanks in the upper right corner as soon as they receive the test. They may use their own pencils. Make certain each subject has a copy of the test. Allow time for the blanks to be filled.

B. Then say, "READ THE INSTRUCTIONS WHILE I READ THEM ALOUD." Read the instructions on the first page aloud.

C. After one minute ask for the answers to samples Y and Z and work them through on the board. Say, "IS THERE ANYONE WHO DOESN'T UNDERSTAND?"
Sample Y: (B) NOW YOU ARE WHERE
Sample Z: (B) WWHHEERREE AARREE YYOOUU NNOOWW

D. Then say, "ARE THERE ANY QUESTIONS?" After answering any questions, say, "YOUR WORK WILL HELP US FIND OUT HOW PEOPLE LEARN NEW PRINCIPLES. REMEMBER YOU ARE TO TRY EACH PROBLEM BEFORE YOU GO ON TO THE NEXT. IF YOU HAVE ANY QUESTIONS ABOUT WHAT YOU ARE SUPPOSED TO DO, RAISE YOUR HAND AND I WILL COME TO YOU. DO YOUR BEST. BEGIN THE TEST PROBLEMS."

E. Try to answer all questions by repeating the appropriate part of the instructions. Do not give any clues or hints concerning the problems or their solution. Circulate among the subjects to see if any have not understood the directions and to discourage copying.

F. The recommended time for this test is a minimum of 50 minutes but all work should be stopped at the end of an hour.

G. At the end of the test period say, "STOP. PUT DOWN YOUR PENCILS. PASS IN THE TESTS."

Name _____
Date _____

CRYPTOANALYSIS TEST I

Form A

INSTRUCTIONS

This is a test of your ability to figure out codes and to write messages in them. There are 24 codes in this test. For each code problem you will find Message (A) on the left side of the page. Below it Message (A) will be rewritten in the code. On the right side of the page you will find Message (B). You are to rewrite Message (B) in the same code. Write Message (B), in code, on the line below Message (B).

In each odd numbered code problem you will be given a rule for the code. In the even numbered problems no rule will be given. Try each problem before going on to the next one. In sample problems X and Y now,

Sample X. Write the words in reverse order.
(A) WE ARE HERE (B) CLOSE ARE YOU NOW

HERE ARE WE _____

Sample Y.
(A) WE ARE HERE (B) CLOSE ARE YOU NOW

HERE ARE WE _____

NOTE: Wait until your instructor says, "Begin the next problem."

MAY PROBLEM

1. Write the letters of the message in reverse order.
(A) THEY HAVE COME (B) SEND FOUR CARS NOW

EMOC EVAH YEHT _____

2. (A) THEY HAVE COME (B) SEND FOUR CARS NOW

TRELSEVE RELEVERE
CEOLMELS _____

3. For each letter in the message substitute the letter that follows it in the alphabet.
(A) THEY HAVE COME (B) SEND FOUR CREWS NOW

UIFZ IBWF DPNF _____

4. (A) THEY HAVE COME (B) SEND FOUR CREWS NOW

HTYEAHEVOCEM _____

5. Write the odd numbered letters then write the even numbered letters. (Count straight through the message to determine which letters are odd and which are even.)
(A) WHEN SEEN LAST (B) NOT AFTER SIX TODAY

WESELS HNENAT _____

6. (A) WHEN SEEN LAST (B) NOT AFTER SIX TODAY

VGDM RDDM KZRS _____

7. For each odd numbered letter substitute the first letter following it in the alphabet; for each even numbered letter substitute the second letter following it in the alphabet. (Count straight through the message to determine which letters are odd and which are even.)
(A) WHEN SEEN LAST (B) NOT AFTER SIX TODAY

XJFFTGFPMCTV _____

8. (A) WHEN SEEN LAST (B) NOT AFTER SIX TODAY

NEHW NEES TSAL _____

9. Alternate the letters of the message with the letters of the alphabet in order starting with "A".
(A) RIOT AND WHAT (B) FIRE WHEN DARK BEST

RAIBOCTDAENFDGWHHIAJTK _____

10. (A) RIOT AND WHAT (B) FIRE WHEN DARK BEST

QGNRZLCUGYS _____

11. For each letter substi[illegible] letter before it and the letter after it in the alphabet.
(A) RIOT AND [illegible] (B) FIRE [illegible] DARK BIRD

QSHJNPSUZBMOCDV GIZBSU _____

12. (A) RIOT AND WAIT (B) FIRE WHEN DARK BIRD

RAW INH CDA TT _____

13. In each word for the first letter substitute the first letter after it in the alphabet, for the second letter substitute the second letter after it in the alphabet, etc.
(A) WANT TWO MORE (B) SPELL BACK EACH ONE

XCQX UYR NQUI _____

14. (A) WANT TWO MORE (B) SPELL BACK EACH ONE

TMNNAOWP CQWRTS ETRUOVMW _____

15. Write the last letter of each word then the second from last letter of each word, etc.
(A) WANT TWO MORE (B) SPELL BACK EACH ONE

TOE NWR ATC WN _____

16. (A) WANT TWO MORE (B) SPELL BACK EACH ONE

XZOSUVPLPQP _____

17. Write odd numbered letters as they are; for each even numbered letter substitute the letter after it in the alphabet. (Count straight through the message to determine which letters are odd and which are even.)
(A) AFTER EACH RUN (B) LIST JOBS DONE NEXT

AGTFREADHSUO _____

18. (A) AFTER EACH RUN (B) LIST JOBS DONE NEXT

SCJES GCET CSQ _____

19. For each odd numbered letter substitute the first and the next letters after it in the alphabet. For each numbered letter substitute the second and first letters before it in the alphabet. (Count straight through the message to determine which letters are odd and which even.)
(A) AFTER EACH RUN (B) LIST JOBS DONE NEXT

BCDEUVCDSTCDBCABIJPQVWLM

20. (A) AFILR EACH RUN (B) LIST JOBS DONE NEXT

CFHGVUGFTS GFCBEDJI
TSWVPO

21. For each letter substitute the second letter before it in the alphabet; alternate with the letters of the alphabet in order beginning with "F".
(A) NEED REPLY NOW (B) WHO SENT THIS GROUP

LFCGCHBI PJCKNLJMYN
LCMPUQ

22. (A) NEED REPLY NOW (B) WHO SENT THIS GROUP

NFCD QENLV MOU

23. Reverse the letters in each pair then for each substitute the second letter after it in the alphabet.
(A) NEED REPLY NOW (B) WHO SENT THIS GROUP

GPFGGTVRPAYQ

24. (A) NEED REPLY NOW (B) WHO SENT THIS GROUP

MKADBEDBIGAO QCEDBAOMEMKIJXVO
MKONLAVTE

Name _____
Date _____

CRYPTANALYSIS TEST I

Form B

INSTRUCTIONS

This is a test of your ability to figure out codes and to write messages in them. There are 24 codes in this test. For each code problem you will find Message (A) on the left side of the page. Below it Message (A) will be rewritten in the code. On the right side of the page you will find Message (B). You are to rewrite Message (B) in the same code. Write Message (B), in code, on the line below Message (B).

In each odd numbered code problem you will be given a rule for the code. In the even numbered problems no rule will be given. Try each problem before going on to the next one. Do sample problems Y and Z now.

Sample Y. Write the words in reverse order.
(A) WE ARE HERE (B) WHERE ARE YOU NOW

HERE ARE WE _____

Sample Z.
(A) WE ARE HERE (B) WHERE ARE YOU NOW

WWEE AARREE HHEERREE _____

STOP: Wait until your instructor says, "Begin the test problems".

TEST PROBLEMS

1. Alternate the letters of the message with the letter "E".
(A) THEY HAVE COME (B) SEND FOUR CREWS NOW

TEHEEEYE HEAEVEEE
CEOEMEEE _____

2.(A) THEY HAVE COME (B) SEND FOUR CREWS NOW

EMOC EVAH YEHT _____

3. Divide the message into pairs of letters; reverse the letters in each pair.
(A) THEY HAVE COME (B) SEND FOUR CREWS NOW

HTYEAHEVOCEM _____

4. (A) THEY HAVE COME (B) SEND FOUR CREWS NOW

UIFZ IBWF DPNF _____

5. For each letter in the message substitute the letter that is before it in the alphabet.
(A) WHEN SEEN LAST (B) NOT AFTER SIX TODAY

VGDM RDDM KZRS _____

6. (A) WHEN SEEN LAST (B) NOT AFTER SIX TODAY

WESELS HNENAT _____

7. Write the letters of each word in reverse order.
(A) WHEN SEEN LAST (B) NOT AFTER SIX TODAY

NEHW NEES TSAL _____

8. (A) WHEN SEEN LAST (B) NOT AFTER SIX TODAY

XJFPTGFPMCTV _____

9. For each odd numbered letter substitute the first letter before it in the alphabet; for each even numbered letter substitute the second letter before it in the alphabet. (Count straight through the message to determine which letters are odd and which are even.)
(A) RIOT AND WHAT (B) FIRE WHEN DARK BEST

QGNRZLCUGYS _____

10. (A) RIOT AND WHAT (B) FIRE WHEN DARK BEST

RAIBOCTDAENFDGWHHIAJTK _____

11. Write the first letter of each word, then write the second letter of each word, etc.
(A) RIOT AND WHAT (B) FIRE WHEN DARK BEST

RAW INH ODA TT _____

12. (A) RIOT AND WHAT (B) FIRE WHEN DARK BEST

QSHJNPSUZBMOCEVXGIZBSU _____

13. Write the letters of each word in reverse order and alternate with the letters of the alphabet in order starting with M.
(A) WANT TWO MORE (B) SPELL BACK EACH ONE

TMNNAOWP OQWRTS ETRUOVMW _____

14. (A) WANT TWO MORE (B) SPELL BACK EACH ONE

XCQX UYR NQUI _____

15. For each odd numbered letter substitute the letter after it in the alphabet; for each even numbered letter substitute the letter before it in the alphabet. (Count straight through the message to determine which letters are odd and which are even.)
(A) WANT TWO MORE (B) SPELL BACK EACH ONE

XZOSUVPLPQF _____

16. (A) WANT TWO MORE (B) SPELL BACK EACH ONE

TOE NWR ATO WM _____

17. In the first word for each letter substitute the letter after it in the alphabet; in the second word for each letter substitute the second letter after it in the alphabet; etc.
(A) AFTER EACH RUN (B) LIST JOBS DONE NEXT

BGUFS GCEJ UXQ _____

18. (A) AFTER EACH RUN (B) LIST JOBS DONE NEXT

AGTFRFADHSUO _____

19. For each letter substitute the second and first letters after it in the alphabet.
(A) AFTER EACH RUN (B) LIST JOBS DONE NEXT

CBHGVUGFTS GFCBEDJI TSWVPO_____

20. (A) AFTER EACH RUN (B) LIST JOBS DONE NEXT

BCDEUVCDSTCDBCABIJPQVWLM _____

21. In each word for the first odd numbered letter substitute the first letter before it in the alphabet, for the second odd numbered letter substitute the second letter before it in the alphabet, etc.; write the even numbered letters in each word as they are in the message. (Count straight through each word to determine which letters are odd and which letters are even.)
(A) NEED REPLY NOW (B) WHO SENT THIS GROUP

MECD QENLV MOU _____

22. (A) NEED REPLY NOW (B) WHO SENT THIS GROUP

LFCGCHBI PJCKNLJMWN
LOMPUQ _____

23. For each letter substitute the first and third letters before it in the alphabet, alternate these pairs with the vowels in alphabetic order.
(A) NEED REPLY NOW (B) WHO SENT THIS GROUP

MKADBEDBICAO QOUDBAOMEKIIXVO
MKUNLAVTE_____

24. (A) NEED REPLY NOW (B) WHO SENT THIS GROUP

GPFGGTNRPAYQ _____

Name _____
Date _____

CRYPTANALYSIS TEST II

Instructions: This is a test of your ability to figure out codes and to write messages in them. There are 24 different codes in this test. For each code problem you will find Message (A) on the left side of the page. Below it Message (A) will be rewritten in the code. On the right side of the page you will find Message (B). You are to rewrite Message (B) in the same code. Write Message (B), in code, on the line below Message B.

Try each problem fefore going on to the next one. Do sample problems Y and Z now.

Sample Y.

(A) WE ARE HERE (B) WHERE ARE YOU NOW

HERE ARE WE _____

Sample Z.

(A) WE ARE HERE (B) WHERE ARE YOU NOW

WWEE AARREE HHEERREE _____

STOP: Wait until your instructor says, "Begin the test problems."

TEST PROBLEMS

1. (A) WHAT TIME BEST (B) HOUR FIVE WILL WORK

   TSEB EMIT TAHW _____

2. (A) WHAT TIME BEST (B) HOUR FIVE WILL WORK

   WEHEAETETEIEMEEEBEEESETE _____

3. (A) WHAT TIME BEST (B) HOUR FIVE WILL WORK

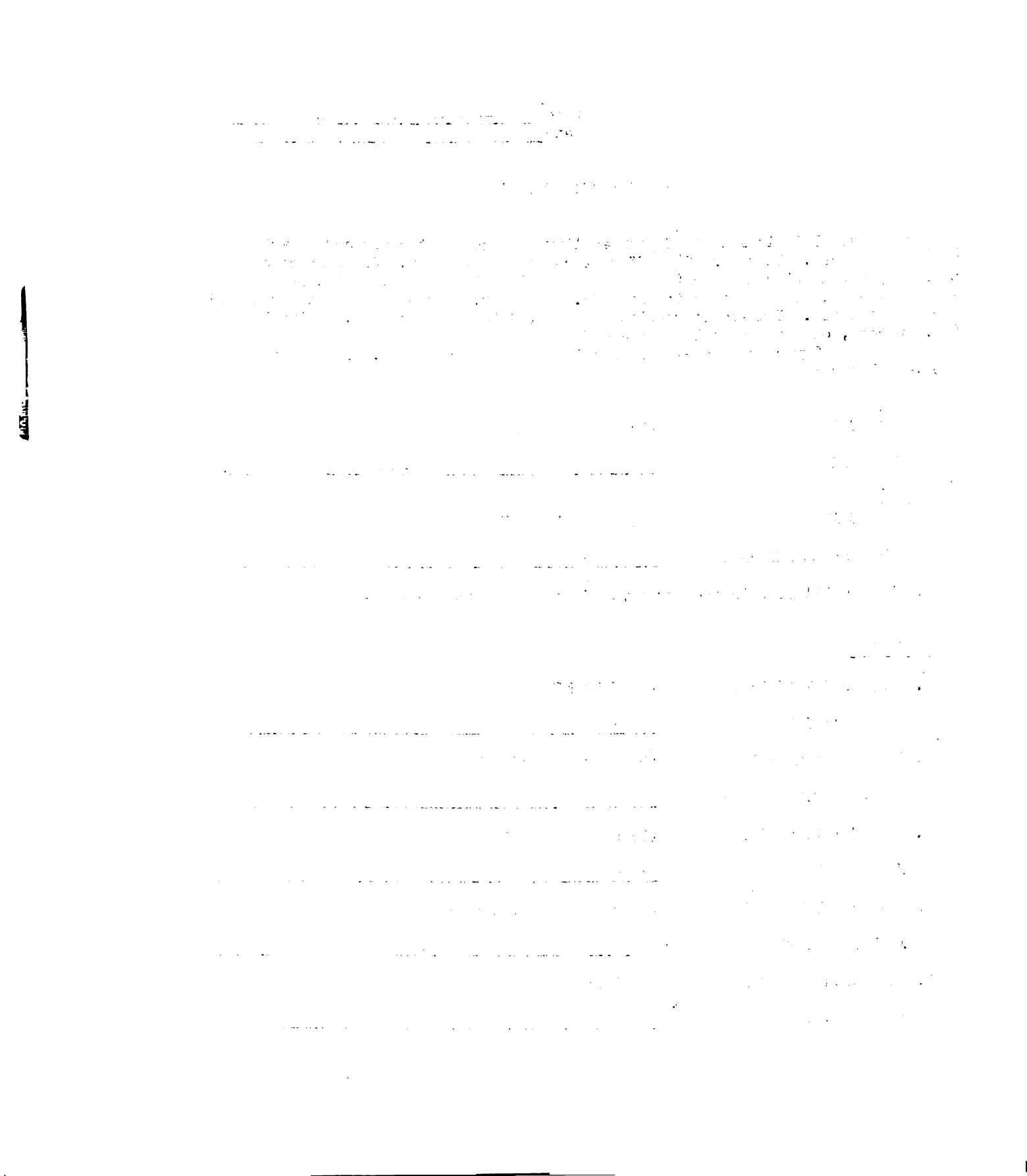
   HWTAITEMEBTS _____

4. (A) WHAT TIME BEST (B) HOUR FIVE WILL WORK

   XIBU UJNF CFTU _____

5. (A) WHICH DOG SOLD (B) ONLY LARGE PUP WENT

   WIHOSL HCDGOD _____



6. (A) WHICH DOG SOLD (B) ONLY LARGE PUP WENT

VGHBG CNF RNKC _____

7. (A) WHICH DOG SOLD (B) ONLY LARGE PUP WENT

HCIHW GOD DLOS _____

8. (A) WHICH DOG SOLD (B) ONLY LARGE PUP WENT

XJJEI FPI TQMF _____

9. (A) NATE SAYS COME (B) JUST WAIT TWO HOURS

NAABTCEDSEAFYGSHCIOJMKEL _____

10. (A) NATE SAYS COME (B) JUST WAIT TWO HOURS

MYSC RYXQ BMLC _____

11. (A) NATE SAYS COME (B) JUST WAIT TWO HOURS

NSC AAO TYM ESE _____

12. (A) NATE SAYS COME (B) JUST WAIT TWO HOURS

MOZBSUDFRTZBXZRTBDNPLNDF _____

13. (A) PRICE DROP DUE (B) SELL OLD STOCK NEXT

QTLGJ ETRT EWH _____

14. (A) PRICE DROP DUE (B) SELL OLD STOCK NEXT

EMCNIORPPQPROSRTDUEVUWDX _____

15. (A) PRICE DROP DUE (B) SELL OLD STOCK NEXT

QQJBF CSNQ CVD _____

16. (A) PRICE DROP DUE (B) SELL OLD STOCK NEXT

EPE COU IRD RD P _____

17. (A) NEWS POOR HERE (B) SOX BEAT OUR TIGERS

NFWT PPOS HFRF _____

18. (A) NEWS POOR HERE (B) SOX BEAT OUR TIGERS

OFXT RQQT KHUH _____

19. (A) NEWS POOR HERE (B) SOX BEAT OUR TIGERS

POGFYXUTRQQPQPTSJIGFTSGF _____

20. (A) NEWS POOR HERE (B) SOX BEAT OUR TIGERS

OPCDXYQRQRMNPQPQLJCDSTCD _____

21. (A) TOMS LOSS HIGH (B) OUR TRUCE FLAG SENT

RFMGKHQLJJMKQLQMFNGOEPFQ _____

22. (A) TOMS LOSS HIGH (B) OUR TRUCE FLAG SENT

SOKS KOQS GIEH _____

23. (A) TOMS LOSS HIGH (B) OUR TRUCE FLAG SENT

SQANLELJIRPO KIUNLARPERPI
GEOHFUFDAGEE _____

24. (A) TOMS LOSS HIGH (B) OUR TRUCE FLAG SENT

QVUO QNUU KJJI _____

Test I, Form A - Answers

1. WON SWERC RUOF DNES
2. SEEENEDE FEOEUERE CEREEEWESE NEOEWE
3. TFOE GPVS DSFXT OPX
4. ESDN OFRU RCWEN SWO
5. NTFE SXOA OATR ITDY
6. MNS ZESDQ RHW SNCZX
7. OQU CGVFT TKY VPFBA
8. TON RETFA XIS YADOT
9. FAIBRCED WEHFEGNH DIAJRKKL BMENSOTP
10. EGQC VFDL CYQI ACRR
11. EGHJQSDF VXGIDFMO CEZBQSJL ACDFRTSU
12. FWDB IHAE RERS ENKT
13. TRHPQ CCFO FCFL PPH
14. LMLNEOPPSQ KRCSATBU HVCWAXEY EZNAOB
15. LKHE LCCN EAAO PBES
16. TOFKM ABBL DBBI NOD
17. LJSU JPBT DPNF NFXU
18. MJTU LQDU GRQH RIBX
19. MNGHTURS KLMNCDQR EFMNOPCD OPCDYZRS
20. NMKJUTVU LKQPDCUT FEQPPOGF POGFZYVU
21. UFFGMH QICJLKRL RMFNGOQP EQPRMSSTNU
22. VHM RELT SHGS FRMUM
23. JYU QPGV VKJI UQTRW
24. VTAGEENLI RPODBUMKASQE SQIGEOHFURPA FDEQOITROOMU

Note: To find the correct answers for Test I, Form B use this same list as follows: for odd numbered questions in Form B use the answer for the next question in this list; for the even numbered questions in Form B use the prior answer in this list.

Test II - Answers

1. KROW LLIW EVIF RUOH
2. HEOEUERE FEIEVEEE WEIELELE WEOEREKE
3. OHRU IFEV IWLL OWKR
4. IPVS GJWF XJMM XPSL
5. OLLR EUWN NYAG PPET
6. NMKX KZQFD OTO VDMS
7. YLNO EGRAL PUP TNEW
8. PPMA MCSIF RVR XGOV
9. JAUBSCTD WEAFIGTH TIWJOK HLOMUNROSP
10. ISRR VYHR SUN FNSQQ
11. JWTH UAWO SIOU TTRS
12. IKTVRTSU VXZBHJSU SUVXNP GINPTVQSRT
13. TGOP PNG TVRGP OGAX
14. LMLNEOSP DQLROS KTCUOVTWSX TYXZEANB
15. TDMK PKER UNDJ ODYS
16. LDKT LLCX EOOE STNS
17. SPXC EBTP USTJ GFRT
18. TPY DGCV RXU XMKIVW
19. UTQPZY DCGFCBVU QPWVTS VUKJIHGFTSUT
20. TUMNYZ ZAFGYZUV MNVWPQ UVGHHICDSTQR
21. MFSGPH RIPJSKALCM DNJOYPEQ QRCSLTRU
22. NUP SRSCB ELYG RELT
23. NLATREQOI SQOQOUTRABZEDBI ECOKIUZXAFDE RPIDBOMKUSQA
24. WQVT WTGE NHIC GUVP